THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. VII.

No. II.—FEBRUARY, 1910.

ORIGINAL ARTICLES.

I.—The Sculpturings of the Chalk Downs of Kent, Surrey, and Sussex.[1] By George Clinch, F.G.S., F.S.A. Scot.

(PLATE VI.)

THE aim of this paper is to offer an explanation of the phenomena intimately related to the sculpturings of the Chalk Downs in the district under review, namely:—

(1) The Dry Chalk Valleys.
(2) The River System of the Wealden area, as far as it relates to the Chalk Downs.
(3) Incidentally, the Denudation of the Wealden area.

The various sculpturings of the Chalk Downs fall naturally into two main groups, viz.:—

(1) Dry Valleys, comprising—
  (*a*) Simple coombes, or short valleys, without tributary valleys, and
  (*b*) Complicated, sinuous valleys, usually extending for some miles, and with numerous tributary valleys.
(2) Wet Valleys, cut through the North and South Downs, in which flow rivers which drain the Wealden area.

The chief characteristics of the Dry Valleys (1) are steep, sloping sides, rounded outlines, absence of terraces, general absence of deposits of flints, etc., and proportionately large area of valley as compared with unsculptured areas.

The simple coombes or short valleys (*a*) are found usually on the Chalk escarpment opposite the Weald, and are remarkable for their steepness, both of sides and the general fall of the level of their deepest parts. (See Pl. VI, Fig. 1.)

The complicated, sinuous valleys (*b*) are found usually on the northern slope of the North Downs and the southern slope of the South Downs. The number of tributaries and the breadth of the valleys are two remarkable features to which no one yet seems to have drawn particular attention. They are points which certainly do not appear to have been sufficiently explained by the theories hitherto advanced by geologists. If at first they seem to present difficulties, these very difficulties are of the greatest value as indicating

[1] This paper is substantially the same as that communicated to the Geological Society of London, April 7, 1909, certain revisions having been made subsequently. A short abstract only was printed in the Q.J.G.S., vol. lxv, pp. 208–9.

the direction in which we may look for an explanation of the whole story of the origin and development of the valleys of the Chalk Downs.

Excellent examples of valleys of this type are to be found in abundance in the North and South Downs, in the former especially to the south of Croydon, in West Kent, and throughout the eastern portion of Surrey. (See Fig. 1.)

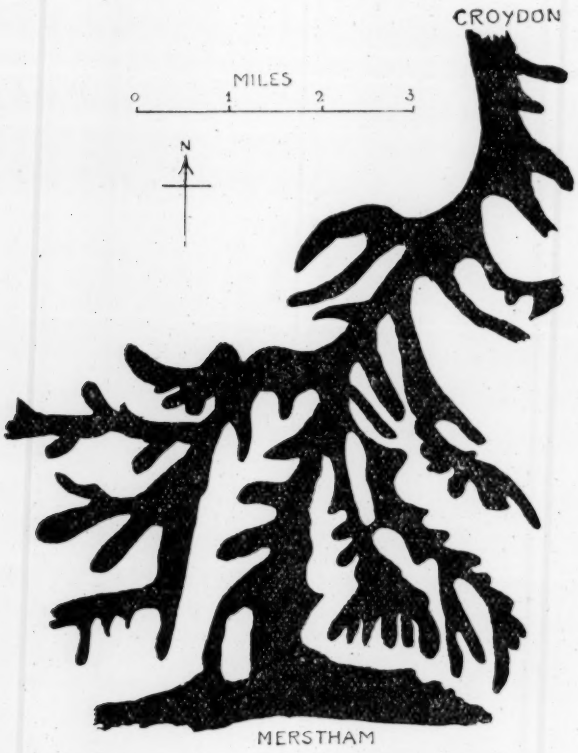


Fig. 1. Diagram showing complicated and sinuous Dry Chalk Valleys of the North Downs between Merstham and Croydon, Surrey.

The Wet Valleys (2) are characterized by the large size and breadth of their passages through the Downs, and by the extensive watersheds drained by the rivers which now occupy them. In general outline and character they are not unlike the Dry Valleys, but they are invariably cut to a lower level in the Chalk, and in all cases, I think, they contain deposits of river gravel. Generally speaking, however, they are of less complicated form than the Dry Valleys. The following rivers now occupy the Wet Valleys of the district with which the present paper is concerned: (*North Downs*) Wey, Mole, Darent, Medway, Stour; and (*South Downs*) Cuckmere, Ouse, Shoreham River or Adur, and Arun.

The neighbourhood of Beachy Head presents many interesting points which illustrate the sculpturing of the Chalk Downs. The Chalk here ends abruptly in a lofty cliff, which once extended much farther to the south. The western slopes of the Downs in this part of Sussex are somewhat precipitous and form part of the watershed of the River Cuckmere, an important watercourse whose most distant source may be traced to Heathfield Park. The river has several tributaries, and drains a large part of the Sussex Weald. Its former importance is indicated much more vividly by the valley through which it flows than by the present volume of its waters.

Between Cuckmere Haven and Birling Gap the sea-coast presents a remarkable series of gable-like cliffs, known, from the number of its eminences, as the Seven Sisters (see Pl. VI, Fig. 2). These elevated points of Downland are divided by eight valleys leading in a practically north and south direction, but six of them are short and of simple form, dying out about a mile to the north of the sea-coast. The others are of more complicated form. It is clear that they all form parts of a complete system of branching valleys, which formerly drained the district. All the southern part has been eroded by the sea, and what may be called the midrib of the series was situated

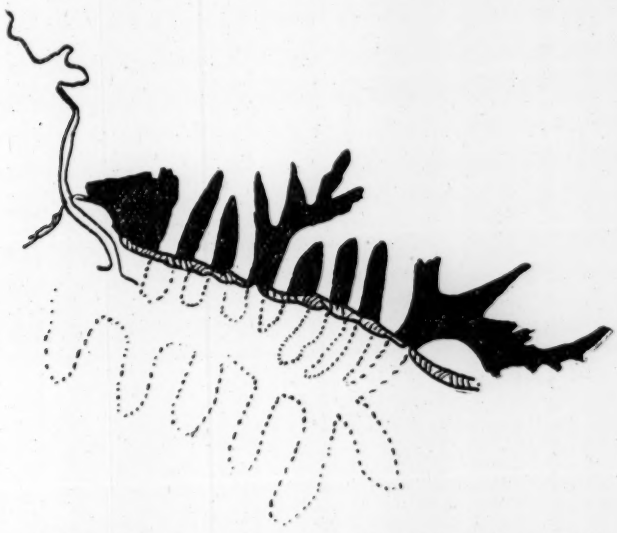


Fig. 2. Diagram showing the Dry Chalk Valleys of the 'Seven Sisters', and a suggested restoration of the valley system in the neighbourhood.

perhaps within 2 miles of the present coastline (see Fig. 2). The destruction of this series of dry valleys was probably due partly to marine erosion and partly to the forces which excavated the valley through which the Cuckmere River now flows. The nature of those forces will be considered at a later stage in the paper.[1]

[1] See a paper "On the Geology of the Neighbourhood of Seaford", by J.V. Elsden: Q.J.G.S., vol. lxv, pp. 442–61.

Deposits in the Dry Valleys.

Generally speaking the Dry Chalk Valleys do not contain any considerable amount of deposits of hard and insoluble matter. Many are indeed quite free from such accumulations; but some are partially occupied by beds of re-arranged Chalk; chalky matter interspersed with sand from the Wealden beds; flints, worn and unworn; ferruginous sandstone from the Lower Greensand; and masses of Sarsen Stone.

An important and significant deposit occupies the bottom of the valley at Purley, near Croydon, a valley which, although now dry, once formed the upper part of the Wandle Valley (Fig. 1) when that river drained part of the Weald. It contains blocks of Sarsen Stone of large size, weighing about a ton, large blocks of equal weight of pebbly conglomerate, and numerous subangular flints as well as Tertiary pebbles. A good section of this was exposed when the waterworks at Purley were constructed. Sarsen blocks of smaller size, and chalky material and flints occur in the Coombe Rock at Black Rock near Brighton.

Denudation of the Weald.

The relation of Chalk sculpturings to the denudation of the Weald was probably intimate. Strictly considered, it is clear that the very sculpturings with which this paper deals are but part of the process of the uncovering of the Wealden strata, by the erosion of the Chalk and other superincumbent deposits. Nevertheless the paucity of remains of the harder and more insoluble parts of the Chalk in the Wealden area is well known, and this circumstance has given rise to an extraordinary variation of opinions amongst geologists as to the force or forces which have removed the Chalk. The elevation of the centre of the Weald is another important point, and unquestionably it has had much to do with this denudation. How far the actual upheaval may have broken up the Chalk cannot now be estimated with precision. There can be no doubt that there was much dislocation and disruption, although the views expressed by some writers[1] on the subject seem to be extravagant.

The Wet Valleys which cut through the Downs are probably the channels by which the eroding and transporting forces conveyed the material to other areas outside the Weald. What those forces in all probability were is a question upon which I shall have occasion to touch when dealing with the origin of the dry valleys; but, I may add, I do not for a moment suggest that anything of the nature of glaciers was the transporting force.

Relation of Dry Chalk Valleys to Clay-with-Flints.

The origin of Clay-with-flints on the higher Chalk has long been a disputed point. Geologists are by no means agreed as to whether

[1] In *Scepticism in Geology* (pp. 44-5), William Longman suggested that "the Chalk escarpments may have been parted asunder like the sinews of a shoulder of mutton on the application of a knife"; and Sir Henry Howorth in *Ice or Water*, vol. i, p. 525, holds that the Chalk beds were dragged apart over the softer underlying strata for a distance of 25 miles. To my mind such an extended movement of the Chalk seems unlikely.

it is a mechanical or a chemical deposit; but, I think, the study of its phenomena in connexion with the dry valleys of the Chalk tends to show that it was due to mechanical rather than chemical agencies. It lies mainly on the table-lands of the Chalk, and is rarely found in the valleys except in a re-arranged condition or as rainwash.

The extreme probability that its material was derived in the first instance from the dissolution of the Chalk does not, I submit, militate against the possibility of its subsequent re-arrangement by mechanical agencies.

The presence of clay-with-flints on the Chalk plateau and its absence from the valleys are points well shown in Kent. A good example to the east of the River Darent has been figured in one of the admirable papers of the late Sir Joseph Prestwich.[1]

River Systems.

It will not be necessary, for the present purpose, to go deeply or fully into the river system of the Weald; but the fact that many of them flow through channels which cut transversely through the Chalk Downs, both north and south, is important as pointing to a very early system of watercourses which drained not only the Wealden area as we know it, but the Wealden dome before it was bereft of its Chalk and Tertiary beds.

The valleys of the Wye, the Mole, the Medway, the Cuckmere, the Ouse, the Shoreham River (now called the Adur), and the Arun are broad and important. The Darent Valley is less marked. That of the Wandle is well-defined, but dry in its upper part, having had its catchment area cut off by the rapid development of the Gault valley. The old valley of the Ravensbourne, the main part of which is now dry, goes quite as far south as the Chalk escarpment, and probably once drained a small part of the Wealden dome. The chief point of interest of all these valleys is that they run transversely to the lines of the Chalk ridges, and point to an ancient drainage system.

The fact that the gravels in these valleys contain materials brought from the Wealden side of the Chalk escarpment is another of the interesting points in their geological history.

Theories on the Denudation of the Weald and the Formation of Valleys.

The papers "On the Anticlinal Line of the London and Hampshire Basins", by Peter John Martin, F.G.S., are of great value. They are, in fact, a storehouse of information to which Lyell and many subsequent writers have turned for inspiration and facts. Martin's papers were published in the *Philosophical Magazine* in 1851, 1854, and 1857, but they deal with observations made as early as 1828. After discussing the various phenomena of the Weald, he writes:—

"To conclude: the obvious inferences to be drawn from what we have seen are these:—

"Since the deposition of the tertiary beds a great and sudden upheaval of some parts, and perhaps contemporaneous subsidence of others, took place over a widely extended area; perhaps over the greater part of the South of England.

[1] Q.J.G.S., vol. xlvii, pl. vii. See also Jukes-Browne, ibid., vol. lxii, p. 132.

"That the phenomena of the arrangement of valleys, and of watersheds, over all the length and breadth of the anticlinal line of the London and Hampshire basins, respond to this convulsion.

"That this convulsion was attended or immediately followed by a devastating flood, which excavated and carried off the broken materials, and only left a small quantity of drift to attest its agency; and that this inundation subsiding, the waters withdrew at once, a period of tranquillity succeeding, which has continued up to the present time."

Mr. Clement Reid's paper,[1] "On the Origin of Dry Chalk Valleys and of Coombe Rock," was published twenty-two years ago, and I think all geologists will admit the value of his contribution to the subject of Chalk hill-sculpture.

Mr. Reid commenced his paper by pointing out the intimate relation of Dry Chalk Valleys and Coombe Rock, a position which I suppose no one would now wish to challenge. After a description of the seaward side of the South Downs, and of the general features of Dry Chalk Valleys, the author proceeded to discuss the various theories advanced by geologists to account for the erosion of the Dry Valleys. He cited three theories, viz.:—

(1) Former submergence, and consequent rise in the plane of saturation.
(2) A former higher level in the plane of saturation before the valleys had been cut to their present depth.
(3) An enormous increase in the rainfall.

All these theories were dismissed as insufficient to account for the phenomena of the Dry Valleys, although their partial aid in producing them was accepted. Mr. Reid remarks: "If these valleys had been gradually cut back by streams, many of them ought to fall northward to the escarpment, where most of the large springs are found; but nearly all the Chalk Coombes follow the general slope of the ground and open to the south."

The most important part of Mr. Reid's paper is that in which he deals with the question of the origin and method of erosion of the valleys. Judging from the flora and fauna, he assumes that the temperature of North-West Europe, at the period under review, was probably 30° lower than it is now. He writes:—

"This would give a mean temperature in the South of England very considerably below the freezing-point; consequently all rocks not protected by snow would be permanently frozen to a depth of several hundred feet. This would modify the entire system of drainage of the country in a way that I do not think has been realized. All rocks would be equally and entirely impervious to water, and all springs would fail. Whilst these conditions lasted any rain falling in the summer would be unable to penetrate more than a few inches. Instead of sinking into the Chalk, or other pervious rock, and being slowly given out in springs, the whole rainfall would immediately run off any steep slopes like those of the Downs, and form violent and transitory mountain-torrents. These would tear up a layer of rubble previously loosened by the frost and unprotected by vegetation. The material carried away would not have the Chalk washed or dissolved out, for a single flood of this description could have little solvent power, and much of the Chalk might not be thoroughly thawed.

"Each of these floods would have an enormous scouring and transporting power; for the fall in the valleys is very great. It is noticeable that no Coombe Rock is found in the valleys that have a greater slope than 100 feet to the mile, and that the main mass is deposited south of the Downs where the slope is much less."

[1] Q.J.G.S., vol. xliii, pp. 364–73.

In the discussion to which Mr. Reid's paper gave rise, the most remarkable view on the subject was expressed by Professor Seeley, who attributed the Dry Valleys mainly to marine erosion. He suggested, too, that the deposit of Clay-with-flints had been swept into its present position by 'tidal waves' at the time when the land was being submerged and the waters were working up the valleys.

Sir A. Geikie remarked that the valleys were doubtless outlined before the Chalk was exposed at the surface, and then subsequent erosion in the Chalk had been effected by solution and mechanical abrasion under conditions which have now disappeared.

Topley referred the origin of Dry Chalk Valleys to the action of 'running water' on land that was solidly frozen.

It will be observed that several authorities were inclined to ascribe the origin of the valleys to the erosion of running water. Seeley's theory as to marine action may be dismissed, perhaps, as lacking both proof and probability, but Topley's suggestions as to 'running water', and Mr. Reid's as to summer floods, are, I venture to think, scarcely less inapplicable.

If water, even in the form of 'mountain-torrents', as Mr. Reid suggests, was the excavating force, we should expect to find (1) a sufficient watershed, (2) terraces on the sides of the valley representing different stages in the volume and velocity of the torrent, and (3) a deposit of hard and insoluble matter, such as flints and other debris of the Chalk. The first and second of these features are lacking, and the third is by no means constant.

Since the publication of Mr. Reid's paper geologists have sought in other directions for explanations of the Dry Chalk Valley systems. One of the theories most in fashion in recent times is that known as the 'solution' theory, by which pluvial activity is invoked, and the whole of the phenomena of Chalk sculpturings is by some referred to the solvent influence of rain and atmosphere.[1]

The direction of the Dry Valleys, we are told, was determined by the courses of streams and rivers on the surface of the Chalk plateau in remote times. The effect was to remove the clay capping and thus lay bare the soluble Chalk to the influences of rain and atmosphere. Every part which was bereft of its clay protection became in time, after a long series of years, hollowed out into valleys.

I am bound to say that this theory, ingenious as it is, gives, to my mind, far too great importance to (1) the solubility of the Chalk, and (2) the influence of rainfall. Indeed, I think such a theory is insufficient to account for certain definite and fairly constant characteristics of these sculptured channels, the most important and obvious of which are (1) the sinuosities of the valleys, (2) their elaborate and complicated forms, (3) the general downward inclination of the valleys towards their outlets, and (4) the presence of rolled chalk, flints, etc., in the valleys themselves.

That erosion rather than solution was the active force in the formation of some of the dry chalk valleys is shown by deposits of high-level gravels having been cut through. Now, it is obvious

[1] See G. W. Young, Proc. Geol. Assoc., 1905, vol. xix, p. 191.

that if the valley were due to solution the gravel would have been let down with the lowering surface of the chalk, but the fact that it has been entirely swept out of the valley affords clear proof of erosion. There is abundant evidence of this, but for the present purpose it will suffice if reference is made to the excellent example in the Seaford district to which Mr. J. V. Elsden has recently drawn attention in his paper,[1] already mentioned, on the geology of that neighbourhood.

That a certain amount of sculpturing of the Chalk may be attributed to solution, either pluvial, or atmospheric, or both, particularly in association with joints or faults, is well known and indisputable. An excellent example may be seen at Box Hill, near Dorking, in Surrey, and there are many others. But in these the bottom of the depression is not regularly inclined downwards, like those of the typical Dry Valleys.

Moreover, the solution theory leaves us much in want of some reasonable controlling force which, in the initial and early stages, would give form to the complete and elaborate valley system. If the solution theory were accepted we should expect deep ravines in the Chalk, following precisely or nearly the direction of the original stream or river which removed the clay capping. A certain broadening would doubtless follow in the course of time, but we should not expect such elaboration and development as we actually find. The erosion would be in the direction of depth rather than breadth, because the degraded clay on the sides of the valleys would still continue, to some extent, to protect the Chalk from rainfall and consequent solution. In a word, the solution theory involves vertical rather than lateral development, yet lateral development is one of the most noteworthy characteristics of the valleys.

Another weak point, among many, about the solution theory is that it fails to account for Dry Valleys on the Chalk escarpment, where there is no controlling and protecting clay covering.

Finally, I submit, the solution theory is effectually disproved by the rolled material in the valleys.

Mr. Reid's suggestion that upon the approach of mild temperature floods like mountain-torrents swept the loosened material out of the Chalk valleys, makes no sufficient allowance, I think, for the vast masses of ice which, wholly or in part, must have occupied the valleys. The presence of these ice-masses must have tended to lateral erosion and consequent widening of the valleys.

The porous nature of Chalk is a point with which Mr. Reid deals thoroughly, and I think his theory that the bed was rendered impervious by means of frost is one which has generally been accepted by geologists. But I do not think it at all likely that the frost extended downwards into the earth for some hundreds of feet, because there would doubtless be a protecting covering of snow. Ten or twenty feet would be ample to render the Chalk impervious, and I cannot find evidence of frost at a greater depth.

Those who have hitherto attempted to explain the denudation of the Weald and the formation of the Dry and Wet Valleys of the Chalk

[1] Q.J.G.S., vol. lxv, pp. 142–61.

Downs as due to the erosive action of water, have not, I think, given sufficient importance to the fact that Chalk, of all rocks, is peculiarly sensitive to the disintegrating influence of frost, particularly when the beds are heavily charged with water. The effects of a frost may be seen, when thaw sets in, in every chalk-cutting and chalk-pit. What its effects may have been when these valleys were half-filled with water and the temperature fell very low, it is difficult to realize at the present time; but the work that was accomplished by alternate freezing and thawing is to be seen in the valleys of the Chalk Downs, many of which are eaten back by the disintegrating and disrupting frost into intricate and complicated forms. In some cases this erosion has been carried to the extent of breaking down the divisions between adjacent valleys, and the formation of isolated hills. (See Fig. 1.)

The suggestion I make, then, is that the chief eroding agent was, not the waves and tides of the sea as some have suggested, nor the 'running water', nor the 'mountain-torrents' of others, but the frost itself acting upon Chalk charged or saturated with water.[1]

By this means, I suggest, the valleys were cut back into the Chalk Downs, the development being to a large extent lateral. The frost was most active, I suggest, where the Chalk was wettest, and the waters standing in the valleys half-choked with ice provided precisely the necessary condition to produce the maximum breaking-up of the Chalk.

I have spoken of the relatively small size of the catchment-area as compared with that of the valleys. It had, to me, long been an enigma; but with the explanation I offer, I think, the difficulty disappears, because the eroding forces were contained in the valleys themselves when the Chalk below was impervious and they were partly filled with water. The wet condition of the Chalk may have arisen from partial thaw and not wholly from rainfall.

At the same time it must be borne in mind that the condition of semi-saturation, under which the frosts were most destructive to the Chalk, was most naturally produced when there was some kind of catchment basin. Indeed, it would seem that such a basin was absolutely necessary to produce the requisite conditions, because when the valley was cut back quite near the edge of the Chalk escarpment, and the drainage became insignificant, the hollow channel dies out.

The transporting agencies of floating ice, and the floods arising from the periodical breaking-up of the ice-masses in the valleys would doubtless be sufficient, in the case of the steeper valleys or coombes, to sweep the debris down into the sea or into the valley or estuary of the Thames.

The whole of the phenomena of the Dry Chalk Valleys and other forms of sculpturings of the Chalk Downs may, I submit, be amply accounted for by the forces I have attempted to describe; and if, as seems obvious, the valleys be closely related to the denudation of the Weald, it is perhaps within the region of probability that the latter may have been influenced by the same cause.

[1] On this subject see remarks by S. V. Wood, jun., Q.J.G.S., vol. xxxviii, p. 718.

EXPLANATION OF PLATE VI.

Fig. 1. This photograph of the northern escarpment of the South Downs near Ditchling Beacon affords an admirable illustration of the simple steep coombes to which reference is made in the paper. Ditchling Beacon is shown on the high point about the middle of the view. At the foot of the steep escarpment is shown the ancient hedge which separates the down land from the arable land of the Weald. The latter in prehistoric and early historic times was largely forest land.

,, 2. The Seven Sisters, a series of alternate valleys and lofty cliffs, owe their shapes to a former system of branching dry valleys, much of which has been destroyed, probably by marine erosion.

II.—Notes on the Fossil Flora of the Bristol Coal-field.

By D. G. Lillie, B.A., St. John's College, Cambridge.

(PLATE VII.)

More than twenty-three years have now passed since Dr. Kidston published his memoir on the fossil flora of the Somerset and Bristol Coal-field, and in the meanwhile no further additions to our knowledge have been made. Kidston's paper was chiefly concerned with the plant-remains of the southern or Radstock portion of the basin. Those from the northern or Bristol area have only been studied incidentally. This would seem quite natural on account of the greater size and industrial importance of the Radstock Coal Series, and from the fact that this locality has been long known to yield the finest and best preserved impressions of fossil plants to be found in any coal-field in the British Isles. The collieries in the Bristol district are comparatively few and smaller, fossil plants being much scarcer and less well preserved.

In view of the fact that the Bristol area is becoming less extensively worked every year, it has seemed to me worth while to collect as many plants as possible from this district, in the hope of adding to those already recorded. It also has been desired to obtain a flora sufficiently characteristic to indicate the palæobotanical horizon as compared with those of the Radstock district and other coal-fields. At present the evidence rests entirely on stratigraphical data. With this end in view, I spent some weeks, during the last two summers, in collecting fossil plants from the waste-heaps of the seven collieries which alone appeared to be still working in the Bristol district.

In recent times several collieries have been completely abandoned, including all those on the Nailsea basin, and the possibility of obtaining plant-remains from this coal-field is becoming less every year. The spoil-heaps of four of the collieries now working proved to be almost completely barren on both occasions when I visited them, the shale being much slickensided and all organic remains obliterated. Thus there remained only three collieries from which plants can be collected, and one of these is exceedingly small. A week's work was consequently sufficient each year to practically exhaust the spoil-heaps.

The physical features and stratigraphy of the Bristol district have been described by several writers[1] in the past. In more recent

[1] See Kidston, Trans. Roy. Soc. Edinb., vol. xxxiii. pt. ii, p. 338 note.

years, important and able papers by Mr. James McMurtrie, F.G.S.,[1] and Mr. H. Bolton, F.G.S.,[2] have been added to this list. It will only be necessary to very briefly recapitulate the main characters of the area for the purposes of the present paper.

The Coal-measures of the Somerset and Bristol basin consist of two productive divisions, separated by the Pennant Rock. The upper division, lying above the Pennant, is again divisible into a higher, the Radstock Series, and a lower, the Farrington Series, separated by barren beds known as the Red Shales. The lower division can be also subdivided into the New Rock and Vobster Series, though the line of demarcation between them is less distinct. The succession of the Coal-measures in that part of the basin which intervenes between the Radstock district and the neighbourhood of Bristol is not known with certainty; but the main stratigraphical divisions of the latter appear to correspond with those at Radstock, though it has not been found possible to correlate the coal-seams of the two areas. Indeed, the correlation of many of the seams, even within the Bristol area itself, are either unknown or uncertain.

The following table indicates a comparison of the series in the two districts, and includes the names of the collieries at present working in the Bristol area:—

Radstock Area.		Collieries in the Bristol Area.	
Upper Division (2200 feet)	Rad-tock Series (about eight seams).		Absent.
	Red Shales.		Very thin.
	Farrington Series (six or more seams).	Working same seams	Coal Pit Heath Colliery. Parkfield Colliery. Shortwood Colliery.
Pennant Rock (3000 feet).			
Lower Division (2800 feet)	New Rock Series (eighteen or more thin seams).	Working same seams	Kingswood Collieries (Speedwell Pit, Deep Pit), Easton Colliery.
	Vobster Series (eight or more seams).		Hanham Colliery (?).

We thus see that there are now only three collieries at work in the Farrington Series in the Bristol district. Each, however, is working several seams, and all three have yielded fossil plants; but the exact seam from which they came is unknown. Coal Pit Heath Colliery is probably working higher seams in the Farrington Series than Parkfield and Shortwood Collieries. Two collieries are working, three pits in all, in the New Rock Series, but only one specimen could be obtained from the heaps after repeated searching. The Hanham Colliery, which, it is believed, is working the Vobster Series, has also proved entirely barren as a collecting-ground.

Thus the impressions described here are all derived from the Farrington Series, and these may be compared with the flora of the same series in the Radstock area, already described by Kidston.[3]

So far we have been concerned only with the impressions, but some

[1] McMurtrie, Trans. Inst. Mining Engineers, 1901, vol. xx.
[2] Bolton, Q.J.G.S., 1907, vol. lxiii, p. 445.
[3] Kidston, Trans. Roy. Soc. Edinb., vol. xxxiii, pt. ii, p. 410.

interesting plant petrifactions have also been obtained, and we may commence with a brief notice of these.

Petrifactions.

In addition to impressions found in the shale bordering on the coal-seams, a limited amount of petrified material has also been obtained, which is of special interest, because our supply of structure material has hitherto been confined to one or two seams in the Lower Coal-measures of Yorkshire and Lancashire. This material was originally recognized by Mr. Bolton, F.G.S., Curator of the Bristol Museum, who drew my attention to it. It has only been obtained at one locality, Staple Hill, about 3 miles to the north-east of Bristol, on the north side of the Kingswood anticline. A sinking was made here a year or two ago, through the Pennant Grit, but was afterwards abandoned at a point rather beyond the base of the Pennant. At this level a peculiar breccia-conglomerate, containing numerous angular and rounded pebbles, set in a sandstone matrix, was met with in sinking the shaft. This rock will be more fully described by Mr. Bolton. It is only necessary here to add that, in addition to the pebbles, this breccia contains numerous fragments of stems and petioles of plants in some of which the structure is preserved; the material being calcified. The amount of this conglomerate is very limited, and it is very doubtful whether any more can be obtained in the future. Many of the blocks thrown out from the shaft have become considerably weathered, and the plant petrifactions quite spoilt for purposes of section cutting. However, a number of sections have been cut of the petrified material, and several of these proved to be well-preserved stems or petioles. Twigs of *Cordaites* appear to be the commonest fossils, while in addition a well-preserved petiole of *Myeloxylon* has been obtained. It is hoped that an opportunity will be found to describe these structure specimens before very long. At present we must content ourselves with a record of their discovery.

Impressions.

We now pass to a record of the plant impressions obtained from the Farrington Series in the Bristol district.

The following list of plants, recorded by Dr. Kidston in 1887, comprised the entire flora then known from the Farrington Series of this area, and no further additions have been made, as far as I am aware, up to the time of writing:—

	Localities.		
Equisetales.	Coal Pit Heath.	Parkfield.	Puckle-church.
Calamites ramosus (Artis)		×	
Annularia stellata (Schloth.)		×	
Sphenophyllales.			
Sphenophyllum emarginatum, Brongn.		×	
Pteridosperms and Ferns.			
Alethopteris lonchitica (Schloth.)		×	
Neuropteris macrophylla, Brongn.		×	
N. ovata, Hoffman		×	
Pecopteris arborescens (Schloth.)		×	×

Pteridosperms and Ferns (*continued*).	Localities. Coal Pit Heath.	Parkfield.	Pucklechurch.
Pecopteris arcopteridia (Schloth.)	—	x	—
P. pteroides, Brongn.	—	x	—
Rhacophyllum crispum, Guthier	—	x (?)	—
R. Goldenbergi, Weiss			x
Caulopteris macrodiscus, Brongn.	x		—
Lycopodiales.			
Sigillaria reniformis, Brongn.	x		—
S. Voltzia, Brongn.	x		—
S. elongata, Brongn.	—	x	—
Stigmaria ficoides, Sternb.	—	x	—

We now proceed to record the additions which we have been able to make to this flora:—

Equisetales.	Locality.
Calamites Suckowi, Brongn.	Parkfield Colliery.
C. Cisti, Brongn.	Parkfield Colliery.
Calamites sp. (external surface)	Parkfield Colliery.
Annularia sphenophylloides (Zenker)	Coal Pit Heath Colliery, Parkfield Colliery, Shortwood Colliery.
Annularia cf. *radiata* (?), Brongn.	Coal Pit Heath Colliery.
Pteridosperms and Ferns.	
Sphenopteris neuropteroides (Boulay)	Coal Pit Heath Colliery, Parkfield Colliery.
S. ovatifolia, sp. nov.	Coal Pit Heath Colliery, Shortwood Colliery.
Alethopteris Serli (Brongn.)	Shortwood Colliery.
Neuropteris flexuosa, Brongn.	Parkfield Colliery.
N. Scheuchzeri, Hoffm.	Coal Pit Heath Colliery.
Pecopteris polymorpha, Brongn.	Coal Pit Heath Colliery.
P. crenulata, Brongn.	Coal Pit Heath Colliery.
P. Miltoni (Artis)	Coal Pit Heath Colliery, Parkfield Colliery, Shortwood Colliery.
Pecopteris (*Dactylotheca*) *plumosa* (Artis)	Shortwood Colliery.
Mariopteris muricata (Schloth.)	Coal Pit Heath Colliery.
Macrosphenopteris (?) sp.	Parkfield Colliery.
Trigonocarpus Noeggerathi (Sternb.)	Coal Pit Heath Colliery, Parkfield Colliery.
Trigonocarpus sp. (outer surface)	Coal Pit Heath Colliery.
Rhacophyllum spinosum, Lesqx.	Parkfield Colliery.
Schizopteris lactuca, Presl	Coal Pit Heath Colliery.
Lycopodiales.	
Lepidodendron lanceolatum, Lesqx.	Coal Pit Heath Colliery, Shortwood Colliery.
Lepidodendron cf. *L. Glincanum*, Eichw.	Parkfield Colliery.
Lepidophyllum majus, Brongn.	Coal Pit Heath Colliery.
Cordaitales.	
Cordaites angulosostriatus, Grand'Eury	Coal Pit Heath Colliery.

Descriptions of the Specimens.

Two of the determinations above mentioned have not hitherto been recorded from Britain. One of these appears to be a new species of *Sphenopteris*, the other a species of *Lepidodendron*, new to Britain.

SPHENOPTERIS OVATIFOLIA, sp. nov. (Pl. VII, Figs. 4 and 5; Text-figs. 1–3.)

Description.—Smaller ultimate pinnæ, alternate, 15 mm. long, narrow, deltoid in shape. Pinnules ovate or ovate-lanceolate, delicate, 4–5 mm. in length, 2–2·5 mm. broad, confluent above but separate and contracted at the base below, entire when small or lobed when larger, margin slightly sinuate or (?) toothed. Terminal pinnule not seen. Veins distinct, median nerve not extending to apex, lateral nerve single, or once, or more rarely twice, forked, in which case the branches fork widely. Nervation of the *Renaultia* type. (Pl. VII, Fig. 4; Text-fig. 1.) Larger pinnæ, more than 2·5 cm. long. Pinnules ovate-lanceolate, contracted at base, 5–6·5 mm. long with six to eight or more lobes. (Pl. VII, Fig. 5; Text-figs. 2 and 3.) Pinnules sometimes overlapping.[1]

The same species or very closely similar specimens have been collected by Mr. Arber from Kilmersden Colliery, Radstock.[2]

FIG. 1. *Sphenopteris ovatifolia*, sp. nov. Enlarged pinnules to show the nervation. × 4 times nat.

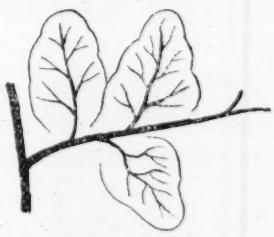


FIG. 2. *Sphenopteris ovatifolia*, sp. nov. Enlarged pinnules to show the nervation. × 4 times nat.

FIG. 3. *Sphenopteris ovatifolia*, sp. nov. Enlarged pinnules showing the nervation. × 4 times nat.

Affinities.—*Sphenopteris ovatifolia*, sp. nov., differs from *Renaultia Footneri* (Marratt) in the pinnules being much larger, in the rachis not being winged, and in the shape of the pinnules. *Renaultia chærophylloides* (Brongn.) was at first thought to be the species to which these specimens belonged; but it is really quite distinct. The

[1] Nos. 2085, 2086, 2087, 2088, 2089, 2090, 2091, 2092, Carb. Plant Coll. Sedgwick Mus., Cambridge.

[2] Nos. 1703, 1704, 1705, 1549, in the same collection.

pinnules of *R. chærophylloides* are more sinuate and much less contracted at the base than in our specimens. *R. schatzlarensis* (Stur) is less like these specimens than *R. chærophylloides*. The pinnules of this species are much more deeply lobed than in our specimens, giving the appearance of a much less massive frond, whereas *S. oratifolia* is less massive than *R. chærophylloides*.

LEPIDODENDRON cf. L. GLINCANUM, Eichwald.[1] (Pl. VII, Figs. 1–3; Text-figs. 4 and 5.)

Description.—Impressions of stems, 15 × 5 cm., showing two states of preservation. The more external impression is probably the external surface very slightly decorticated (as seen at *a* in Figs. 1 and 3, Pl. VII, and in Text-fig. 4). The leaf-bases are small, very elongate, fusiform in shape, each leaf-base being joined to the one above and below by a narrow ridge. Taking the middle points of these ridges as the limits of the individual leaf-bases, each leaf-base is 1·4 cm. long by 1 mm. broad across the greatest width. The cushion is 6 mm. long. The lateral angles are rounded. The leaf-scar is not preserved. There is no ridge, or only a slight indication of a ridge, on the cushion. There is a well-marked narrow ridge between each cushion, which is continuous with the prolongations of the cushions above and below as mentioned above.

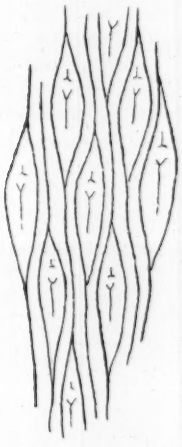


FIG. 4. *Lepidodendron* cf. *L. Glincanum*, Eichw. More external surface. × 3.

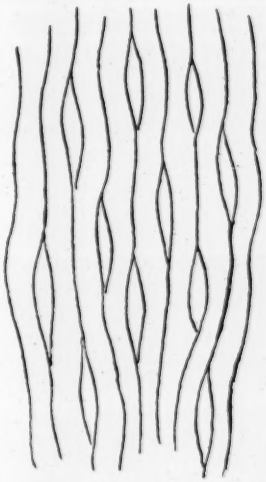


FIG. 5. *Lepidodendron* cf. *L. Glincanum*, Eichw. More decorticated surface. × 3.

The more decorticated surface (seen at *b* in Pl. VII, Figs. 1 and 3, and Text-fig. 5), shows shorter fusiform areas between well-marked flat-topped bands 1 mm. in width.

Attribution of the Specimens.—Though these specimens are not ill preserved, yet they do not show the leaf-scar. Consequently they

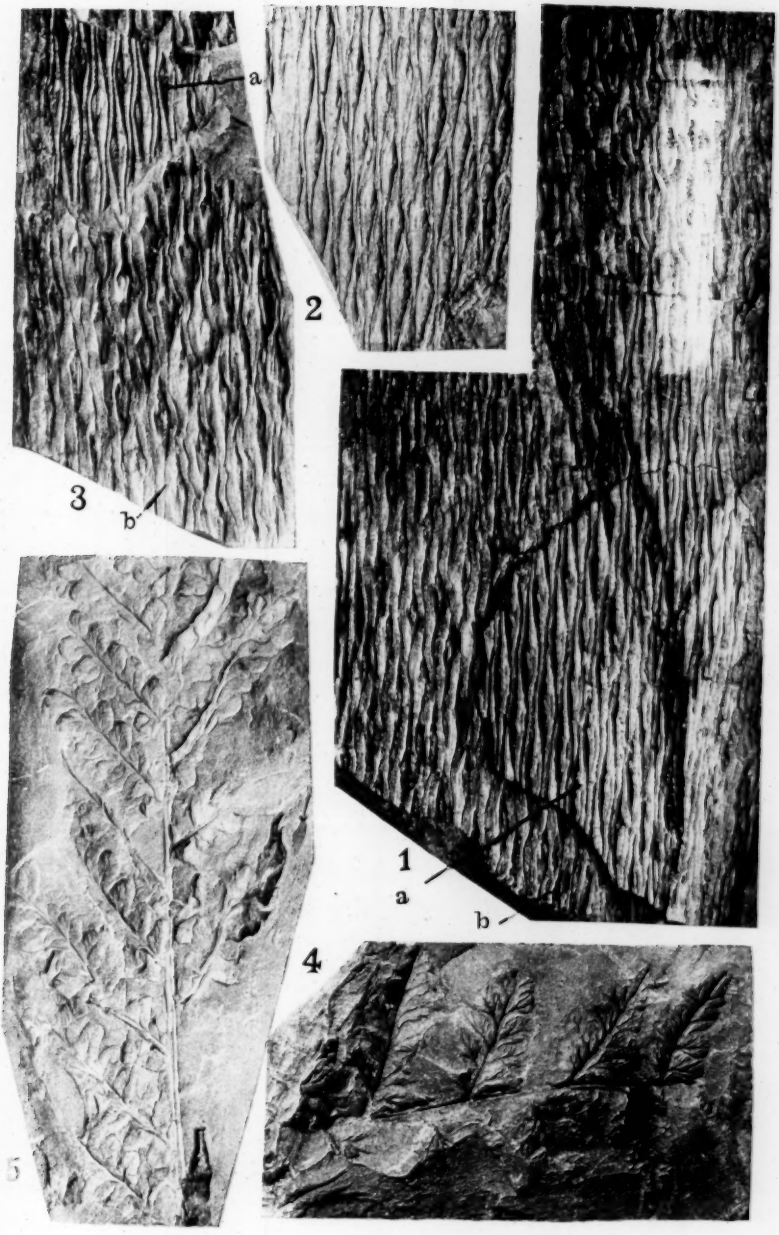
[1] Nos. 2068, 2080, 2081, Carb. Plant Coll. Sedgwick Mus., Cambridge.

cannot be identified specifically. The nearest species appears to be *Lepidodendron Glincanum*, Eichwald, especially the figure on pl. v (*a*), fig. 5 of that author's *Lethæa Rossica*.[1] Also another specimen attributed to this species by Dr. Kidston (pl. v, figs. 41–3),[2] bears a marked resemblance to this fossil. We may, however, first discuss some other species with which comparison may be made. The first of these is *Lepidodendron rimosum*, Sternberg, to which Zalessky[3] attributes Dr. Kidston's figures above mentioned. In the true *L. rimosum* the leaf-bases are much larger, more widely separated by striated bark, while in older stems of the same plant the separation of leaf-bases is even more marked. The leaf-bases in our specimens are much narrower, and more elongate in proportion to their length, than those of *L. rimosum*. Further, the decorticated condition of *L. rimosum* does not correspond to our specimens.

Another near species is *Lepidodendron dichotomum* (Sternberg?), Zeiller, which, however, we believe to be distinct. Zalessky[4] has pointed out, and we understand that Dr. Kidston agrees, that certain of the specimens figured by the latter under the name of *L. Glincanum*[5] should now be referred to *L. dichotomum*. To return to *L. Glincanum*, our specimen is identical with Eichwald's[6] pl. v (*a*), fig. 5, and also to a less extent with figs. 1, 2, and 3; figs. 1 and 5 show the two stages of decortication, just as in our specimens. The specimens attributed by Schmalhausen to the same species—especially of those recently refigured by Zalessky[7]—correspond to our more external surface very fairly, though the leaf-bases are rather larger and the specimens are indifferently preserved. With regard to fig. 14, the correspondence is very close when compared with the decorticated surface of our specimen. The only other specimens so far figured with which we are acquainted are Kidston,[8] pl. v, figs. 41–3. Dr. Kidston's specimens do not show the decorticated stage. We must note that he calls this a variety '*rimosum*', while Zalessky refers it to the species *L. rimosum*. At any rate Dr. Kidston's specimens, from the River Esk, which he regarded as belonging to the Carboniferous Limestone Series, indicate that the locality is almost certainly high up in the Coal-measures.

This group of species, including *L. rimosum*, *L. Glincanum*, and *L. dichotomum*, is one which presents many difficulties, and further evidence may show that these forms are more intimately connected than is supposed. But for the present we have no good grounds for regarding them as other than distinct. The fact that the leaf-bases show no definite leaf-scar is also found to be usually the case in *Lepidodendron lanceolatum*, and may be characteristic of some of the Upper Coal-measure *Lepidodendrons*.

[1] Eichwald, *Lethæa Rossica*, vol. i, "Ancienne Période," p. 127.
[2] Kidston, Trans. Roy. Soc. Edinb., vol. xl, pt. iv, No. 31.
[3] Zalessky, *Mémoires du comité géologique*, N.S., 1908, livraison xiii, p. 88.
[4] Ibid., 1904, livraison xiii, p. 86.
[5] Kidston, Trans. Roy. Soc. Edinb., vol. xl, pt. iv, No. 31, pl. ii, figs. 20 and 21; pl. iv, figs. 37–9.
[6] Eichwald, *Lethæa Rossica*, vol. i.
[7] Zalessky, *Mémoires du comité géologique*, N.S., livraison xiii, pl. iii, fig. 13.
[8] Kidston, Trans. Roy. Soc. Edinb., vol. xl, pt. iv, No. 31.



A. N. A. photos.

Fossil Plants from the Bristol Coal-field.

The following list contains a complete record of the plants at present known from the four divisions of the Bristol district. It will be seen that the flora of the Farrington Series has been increased by twenty-one species, while the fossil flora of the Pennant Rock, the New Rock Series, and the Vobster Series remains as Dr. Kidston[1] recorded it, without a single addition.

FARRINGTON SERIES.

	Coal Pit Heath.	Parkfield.	Short-wood.	Puckle-church.
EQUISETALES.				
Calamites ramosus (Artis)	x	x		
C. Suckowi, Brongn.		x		
C. Cisti, Brongn.		x		
Calamites (external surface)		x		
Annularia stellata (Schloth.)	x	x	x	
A. sphenophylloides (Zenker)	x	x	x	
Annularia cf. *radiata* (?), Brongn.	x			
SPHENOPHYLLALES.				
Sphenophyllum emarginatum, Brongn.	x	x		
PTERIDOSPERMS AND FERNS.				
Sphenopteris neuropteroides (Boulay)	x	x		
S. ovatifolia, n.sp.	x			
Alethopteris Serli (Brongn.)	x			
A. lonchitica (Schloth.)	x	x		
Neuropteris flexuosa, Sternb.	x		x	
N. macrophylla, Brongn.		x	x	
N. ovata, Hoffman		x	x	
N. Scheuchzeri, Hoffman	x			
Pecopteris arborescens (Schloth.)	x	x		x
P. polymorpha, Brongn.	x		x	
P. crenulata, Brongn.	x			
P. Miltoni (Artis)	x	x	x	
P. (*Dactylotheca*) *plumosa* (Artis)			x	
P. oreopteridia, Schloth.		x		
P. pteroides, Brongn.		x		
Mariopteris nitidicata (Schloth.)	x			
Macrosphenopteris (?) sp.		x		
Trigonocarpus Noeggerathi (Sternb.)	x	x		
Trigonocarpus (outer surface)	x			
Rhacophyllum spinosum, Lesqx.		x		
R. crispum, Gutbier		x (?)		
R. Goldenbergi, Weiss				x
Schizopteris lactuca, Presl	x			
Caulopteris macrodiscus, Brongn.	x			
LYCOPODIALES.				
Lepidodendron lanceolatum, Lesqx.	x			
Lepidodendron cf. *Glincanum*, Eichw.	x	x	x	
Lepidophyllum majus, Brongn.	x			
Lepidophyllum (?) sp.			x	
Sigillaria reniformis, Brongn.	x			
S. Voltzia, Brongn.	x			
S. elongata, Brongn.		x		
Sigillaria (?) sp.	x			
Stigmaria ficoides, Sternb.			x	
CORDAITALES.				
Cordaites anguiosostriatus, Grand'Eury	x			

[1] Kidston, Trans. Roy. Soc. Edinb., vol. xl, pt. iv, No. 31.

PENNANT ROCK.

	Crews-hole.	Downend.	Fish-ponds.
EQUISETALES.			
Calamites Suckowi, Brongn.	x	–	–
C. cannæformis, Schloth., sp.?	x	–	–
C. approximatus, Brongn.	x	x	x
LYCOPODIALES.			
'Ulodendron'	–	x	–
'Halonia'	–	–	x
Stigmaria ficoides, Sternb.	near Bristol.		

NEW ROCK SERIES.

	Kings-wood.	Kings-wood, Deep Pit.	Kings-wood, Speed-well Pit.	Warm-ley.	Golden Valley.	Bed-minster.
EQUISETALES.						
Calamites Suckowi, Brongn.	x	–	–	–	–	
PTERIDOSPERMS AND FERNS.						
Sphenopteris trifoliata (Artis)	–	x	–	–	–	
Pecopteris arborescens (Schloth.)	–	–	–	–	x	
P. Miltoni (Artis)	–	–	–	x	x	
LYCOPODIALES.						
Lepidostrobus sp.	x	–	–	–	–	–
'Ulodendron'	–	–	x	–	–	
Sigillaria mamostigma, Lesqx.	–	–	–	x	–	–
S. tessellata, Brongn.	x	–	–	x	–	
S. mamillaris, Brongn.	–	–	–	–	–	
var. *abbreviata*, Weiss	x	–	–	–	–	
S. scutellata, Brongn.	x	–	–	–	–	
S. rugosa, Brongn.	x	–	–	–	–	
S. Schlotheimi, Brongn.	x	–	–	–	–	
Stigmaria ficoides, Sternb.	x	–	–	–	–	x
Cordaites (?) sp.	–	x	–	–	–	

VOBSTER SERIES.

SPHENOPHYLLALES.	
Sphenophyllum emarginatum, Brongn.	Ashton.
PTERIDOSPERMS AND FERNS.	
Pecopteris oreopteridia (Schloth.)	Ashton.
LYCOPODIALES.	
Sigillaria Sillimani, Brongn.	Ashton.
S. mamillaris, Brongn.	Ashton.

A Comparison of the Flora of the Farrington Series in the Bristol and Radstock Districts.

Fifty species in all have been recorded from the Farrington Series of the two districts. Seventeen of these are common to both the Bristol and Radstock areas, while twenty occur at Bristol which have not yet been found at Radstock, and thirteen at Radstock which are as yet unknown from Bristol. We have thus thirty species from the Farrington Series in the Radstock district; and thirty-seven species from the same series in the Bristol district, sixteen of which were recorded by Dr. Kidston and twenty-one by the present writer.

Turning now to a comparison of the Radstock and Farrington Series, only four out of the fifty species known from the Farrington Series are as yet unrecorded from the Radstock Series, which confirms Dr. Kidston's surmise that the two series belong to the same palæobotanical horizon, namely, the Upper Coal-measures. The four plants from the Farrington Series which have not yet been definitely found to occur in the Radstock Series are the following:—

Sphenopteris ovatifolia, n.sp.
Schizopteris lactuca, Presl.
Lepidodendron cf. *Glincanum*, Eichwald.
Sigillaria principis, Weiss.

But as mentioned above (p. 62), a *Sphenopteris*, very like *S. ovatifolia*, has been found in the Radstock Series of Somerset, at Kilmersden, by Mr. Arber.

In conclusion, I would express my special thanks and indebtedness to Mr. Arber for suggesting that I should take up the work in the first place, and for continued help and advice throughout. Many thanks are due to Mr. H. Bolton, F.G.S., of the Bristol Museum, for his kindness in handing over to me the petrified material from Staple Hill for examination; and to Mr. James McMurtrie, F.G.S., of Bristol, for much local help and information.

EXPLANATION OF PLATE VII.

(Photographs by Mr. Arber.)

Fig. 1. *Lepidodendron* cf. *L. Glincanum*, Eichw. Stem showing two states of preservation—(*a*) slightly decorticated outer surface showing the leaf-bases, but not the leaf-scars; (*b*) more decorticated state. × $\frac{3}{2}$. No. 2080. Sedgwick Museum, Cambridge.
.. 2. The same. Portion of the slightly decorticated outer surface, showing the leaf-bases. × $\frac{3}{2}$. No. 2068.
.. 3. Portion of the same stem as Fig. 1, showing two similar states of decortication.
.. 4. *Sphenopteris ovatifolia*, sp. nov. Typical pinnæ. × $\frac{3}{4}$. No. 2089.
.. 5. *Sphenopteris ovatifolia*, sp. nov. A portion of a frond. × $\frac{3}{2}$. No. 2086.

III.—Note on the Faunal Succession in the Carboniferous Limestone (Avonian) near Llantrisant Station in the Bridgend Area, South Wales.

By G. Delépine, Professor of Geology at the Catholic University, Lille.

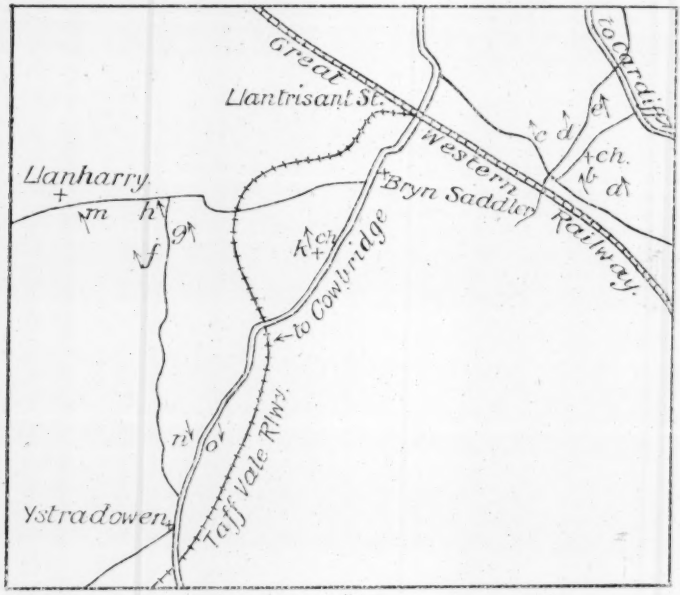
During the autumn of 1909, I made a short excursion into the Bridgend district and examined the Avonian sequence near Llantrisant. The present note embodies the results of a few traverses and suggests a correlation with the sequence already established at other points of the South-West Province.

I herewith acknowledge my indebtedness to Dr. A. Vaughan, F.G.S., for the loan of specially prepared 6 inch maps, and for help in drawing up the faunal lists given below.[1]

The strike of the limestone is generally W.S.W. and the dip N.N.W. in the neighbourhood of Llantrisant and Llanharry (see

[1] The specific identification is that adopted by Dr. Vaughan in his papers on the Avonian.

sketch-map), but near Ystradowen the beds turn over locally and dip S.S.E. (see the new 1 inch map, Geological Survey, Sheet 262).



Sketch-map of the Carboniferous Limestone exposures near Llantrisant Station.

I. *Exposures East of Llantrisant Station, North of the Great Western Line.*

(1) About half a mile east of Miskin church (sketch-map, letter *a*) there are several small and scattered exposures which exhibit a thin-bedded dark-grey encrinital limestone. From these beds I obtained the following Brachiopods:—

Productus burlingtonensis.
Chonetes cf. *hardrensis.*
Orthotetid.
Rhipidomella Michelini.
Spirifer clathratus.
Syringothyris cf. *typa*, Weischell.
Reticularia cf. *lineata.*
Athyris cf. *glabristria.*
Rhynchonellid.

Bryozoa, especially Fenestellids, are very abundant.

(2) About 200 yards north of exposure *a*, in an old quarry (exposure *b*) near the school, black and dark-blue encrinital limestone occurs at the bottom and dolomite with crinoids above.

The limestone yielded—

Corals.

Zaphrentis sp.
Caninia cornucopiæ.

Brachiopods.

Productus burlingtonensis.
P. cf. *pustulosus.*
Chonetes cf. *hardrensis.*
Spirifer clathratus.
Syringothyris laminosa.

The dolomite yielded—

Caninia cornucopiæ.
Syringothyris cuspidata.
S. laminosa (very common).

(3) In a quarry near Hendy Farm, along the road from Miskin to Pontyclun (exposure *e*), encrinital dolomite and massive oolite are observed.

Fauna.

Cyathophyllum ϕ.
Productus corrugatus, var.
Syringothyris cuspidata.
S. laminosa.
Athyris ingens, de Kon. (= *Athyris* cf. *glabistria*, mut. C–S).

(4) Along the road, north of Miskin, which joins the main road from Llantrisant to Cardiff, there are two quarries, to left and right of the road respectively.

In the first of these (exposure *d*) the ascending succession is as follows:—

Encrinital dolomite and oolite.
Thin-bedded black limestone ('china-stone').
Massive oolite.
Blue and grey well-bedded limestone.

The dolomite at the base contains the same fossils as exposure *c* near Hendy Farm.

The upper beds contain—

Lithostrotion Martini.
Productus corrugato-hemisphericus.
Seminula ficoides (abundant).

The second quarry (exposure *e*) lies to the north of the last, and about 100 yards distant.

The oolitic limestone here contains—

Productus cf. *corrugatus*
Prod. corrugato-hemisphericus
Seminula ficoides
} All abundant.

As has been previously noticed, a variant of *Prod. corrugato-hemisphericus* approaches close in form to *Prod. striatus.*

IX. *Correlation of the Limestone East of Llantrisant with the Avonian of the South-West Province.*

The exposures described above fall readily into the following positions on the zonal scale:—

Seminula-zone { S_2 = Exposure *e*.
{ S_1 = Exposure *d* (top of quarry only).

Caninia-zone { C_2 = Exposure *e* and bottom of Exposure *d*.
{ Base of C_1 (γ) = Exposure *b*.

Zaphrentis-zone (pars) = Exposure *a*.

II. *Exposures West of Llantrisant Station, near Llanharry.*

There are several quarries in S_2 and Lower D on the left of the road from Bryn-Sadler to Llanharry.

(1) In a quarry some half-mile south-west of Llanharry Station

(Taff Vale Railway) and on the road from Llanharry to Ystradowen (exposure *f*) the following fossils occur in a massive oolite :—

Lithostrotion.
Carcinophyllum.
Prod. corrugato-hemisphericus, mut. S_2.
Seminula ficoides.

(2) A large quarry and several small ones.

Above this oolite, in a very large quarry (exposure *g*) north of, and close to, Llanharry Station, a well-bedded blue and violet limestone is massively developed.

Here the beds are poorly fossiliferous, but in another quarry (exposure *h*) where the upper beds are worked I collected—

Carcinophyllum θ and fragments of *Campophyllum* and *Productus*.

In a quarry to the east of the last, near a chapel, on the other side of the Taff Vale line, a similar limestone occurs (exposure *k*). This yielded *Productus hemisphericus*, *Chonetes* sp., and Gasteropods.

(3) Close to the village of Llanharry, on the left-hand side of the road from Bryn-Sadler, is an old quarry (exposure *m*) exhibiting thick beds of rubbly limestone. Here I collected—

Lithostrotion irregulare.
Dibunophyllum θ.
Productus near *Martini.*
Seminula ficoides.

IIa. *Correlation of Limestone West of Llantrisant with Avonian Zones.*

Dibunophyllum-zone { D_2 = Exposure *m*.
{ D_1 = Exposure *h*, and perhaps top of large quarry (*g*).
Seminula-zone. S_2 = Exposure *f* and bottom of large quarry (*g*).

III. About one mile north of Ystradowen, on both the right and left of the main road from Llantrisant to Cowbridge, the beds dip in a south-easterly direction.

A quarry on the right (exposure *n*) exhibits dolomite with crinoids; the base of the dolomite yielded—

Syringothyris laminosa (abundant).
Syr. cuspidata (common).
Caninia cornucopiæ.

A quarry on the left (exposure *n*) exhibits, in ascending order—

(1) Massive oolite.
(2) Dolomite with crinoids.
(3) Black limestone.

The beds in (*n*) and (n^1) resemble, both lithologically and palæontologically, the oolitic and dolomitic beds of exposure (*c*), near Hendy Farm, which have been assigned to C_2.

Zonal Sequence

Dibunophyllum-zone { D_2 . . . . *m*.
{ D_1 . . . . *h*, top of *g* (*k*?).
Seminula-zone { S_2 . . . . *e*, *f*, bottom of *g*.
{ S_1 . . . . Top of *d*.
Caninia-zone { C_2 . . . . Bottom of *d*, *c*, *n*, n^1.
{ Base of C_1 (γ) *b*.
Zaphrentis-zone . . . . . *a*.

IV.—On the Origin of the Nile Valley and the Gulf of Suez.[1]

By John Ball, Ph.D., D.Sc., F.G.S.

In Captain Lyons' *Physiography of the River Nile and its Basin* (Cairo, 1906, p. 294), there occurs the following statement:—

"In a trough from 2 to 10 kilometres wide and 100 to 300 metres deep lies the Nile, meandering through a flood plain formed by yearly deposits of silt brought down from the Abyssinian table-land by the Blue Nile and the Atbara. This trough was determined in the first instance by fractures of the crust which caused a strip of country from about Edfu (lat. 25° N.) to Cairo to be depressed, leaving the plateau standing high above it, just as the Red Sea and the gulfs of Suez and Akaba were formed, probably about the same epoch. This interference with the drainage of the country doubtless produced a series of lakes in the low-lying area, while the drainage of the eastern plateau commenced to excavate the valleys which now exist as dry desert wadies, their development being in many cases far from complete, as shown by the cliffs which interrupt the slope of the valley when a harder bed of rock than usual is met with.

"Into this depressed area the drainage of the southern part of the basin finally flowed, and there laid down the alluvial deposit through which the river flows to-day."

A clear and definite pronouncement of this kind, coming from so high an authority as the former Director-General of the Geological Survey of Egypt, is likely to convey the impression that the 'rift theory' of the origin of the Nile Valley and Gulf of Suez is supported by evidence which leaves no room for any other view. This is very far from being the case. To my mind the field-evidences are entirely against the 'rift theory'; they point rather to the Nile Valley being essentially a valley of erosion (though faults or lines of weakness may have had something to do in influencing the river's course), and to the Gulf of Suez being an eroded anticline.

During my twelve years of survey work in Egypt, most of which has been spent in geologizing, I have felt myself becoming increasingly sceptical as to the truth of the 'rift theory' of the orgin of the Nile Valley and the Gulf of Suez. But it was not till the spring of the present year, when I examined the geological structure of the Wadi Araba and part of the Gulf of Suez, that I obtained evidence which appears to be absolutely convincing against the 'rift' view cited above.

The Wadi Araba is a great valley some 20 miles wide, draining north-eastwards into the Gulf of Suez between latitudes 29° 3′ and 29° 22′ N. It divides two great plateaux, the North and South Galala Mountains, which rise to heights of over 4000 feet. The faces of the plateaux which shut in the valley are steep cliffs, in which are exposed a great thickness of Eocene limestones, overlying Cretaceous limestones, marls, and clays, with Nubian Sandstone at the base. The beds, especially the lower ones, have a well-marked dip into the scarp, showing the valley to be an eroded anticline; and this structure is confirmed by the fact that as one crosses the valley, deeper and deeper

[1] By permission of the Director-General, Survey Department.

sandstone-beds come to the surface, until near the centre of the valley one comes on Carboniferous rocks in the form of thin limestone-beds, intercalated in the sandstones, with abundance of such characteristic fossils as *Spirifer* and *Productus*. There is no apparent unconformity anywhere in the series. The upper sandstone beds, which are devoid of fossils, may therefore be here, as in the Nile Valley, of Cretaceous age, though the lower ones are certainly Carboniferous. The apparent absence of any unconformity between Cretaceous and Carboniferous is a very striking fact; but it is not material to the argument concerning structure, the great point in this connexion being the absolute proof, furnished by the succession of fossiliferous beds, and their dips, that the Wadi Araba is an eroded anticline, and thus the very opposite of a rift or trough-fault.

Another very significant feature of the valley is the way in which great masses of the hard Eocene limestones have been let down by landslips at the faces of the limiting scarps, often forcing the softer Cretaceous beds below them outwards into highly-tilted, or even nearly vertical, positions. Two causes may have worked to produce this. The softer, lower beds may have been eroded out so as to undercut the upper, harder ones, and bring about their fall; cracking of the beds may have occurred during the formation of the anticline, which would help in the separation of the masses. Further, it would appear at least a possible explanation that the stresses set up by the daily expansion and contraction of the plateau-surface under the influence of the enormous diurnal variation of temperature may have produced clefts near the free edges of the plateaux; and masses detached in this way on even a slight slope would tend to creep lower and lower under continual expansion and contraction. But whatever the cause of this faulting-down at the face, it is at least certain that it is only landslipping on a large scale, and has nothing to do with the main tectonic structure of the valley. The Wadi Araba is an eroded anticline, its limiting scarps showing in places a step-like structure, due to local slipping down of the hard upper strata at the cliff-face.

I have dwelt thus long on the Wadi Araba, because, while it presents the same phenomena as the Nile Valley and the Gulf of Suez on a magnificent scale, it possesses also the advantage, not shared by them, of being entirely exposed, so that one can examine its floor with the same care and detail as its sides. If the floor of the Wadi Araba were covered with alluvium or water, we should have an almost exact resemblance to the Gulf of Suez and the Nile Valley.

Turning now to the Gulf of Suez, which lies in close connexion with the Wadi Araba, though at right angles to it, an exactly similar, albeit somewhat more restricted, series of observations can be made. Leaving the Wadi Araba, I journeyed northwards along the coast, skirting the scarps of the North Galala plateau, which in places come so abruptly down to the sea that camels have to wade through the sea to round the bluffs. The Carboniferous beds, with their characteristic crinoids, were traced as far north as 29° 30′ of latitude, showing clearly that the eastern foot of the North Galala plateau exposes Carboniferous strata at its base. The North Galala plateau is thus thrust upwards along the western shore of the gulf, the beds dipping

generally westwards. This is confirmed by the gradual rise eastwards of levels of the springs, and of the junction of Cretaceous and Eocene beds as one skirts the north scarp of Wadi Araba.

My observations of the other side of the gulf were only telescopic. But even casual scrutiny of the hills of the opposite shore (Gebel Hammam) showed the beds there to be dipping markedly away from the gulf. Telescopic observations of geological structure are always to be received with caution, but in this case my observations are confirmed by those of my late lamented colleague, Mr. Barron, who, from an actual examination of the place, records[1] that the strata of Gebel Hammam dip 10° eastwards.

So far as general structure goes, therefore, the beds on the two sides of the Gulf of Suez dip away from the gulf, showing the gulf to be an anticline.

The seaward faces of the North Galala plateau exhibit in many places a step-like form due to the faulting down of the strata in the same manner as those of the Wadi Araba, and at several points the faults are cut through by small lateral valleys which allow of their easy examination. The impression produced in all these cases is that of land-slipping at the face of the scarp, and not that of the letting-down of a tract extending across the gulf. One of the best exposures is the north face of a hill-mass in latitude 29° 34′, close to the north-east corner of the North Galala plateau. I climbed this hill, on which I had a trigonometrical station 1295 feet above sea-level, and found its lower part to be composed of yellow-brown and white limestone and marls (Cretaceous), while its upper part was mainly hard limestone, which I believe to be chiefly Eocene with a thin covering of Miocene. The whole of the beds dipped strongly (18° to 25°) towards the main scarp. Standing on the hill-top, one can see, high up on the main scarp to the west, the same Cretaceous limestones and marls which form the foot of the hill, while the hard Eocene limestones cap them at a height of over 2000 feet. Proceeding a short way along the coast north of this hill, one can obtain a very clear view of the faulting. The fault or slip-plane is inclined at only 22° to the horizontal, of course downward from the scarp, and the faulted-down Eocene limestones of the hill abut against the purple and brown sandstones and clays (possibly in part Carboniferous) which form the lower part of the main scarp. The flat angle of the fault-plane is significant, and points far more to a great landslip at the face of the scarp than to organic faulting of the earth's crust. The high dip of the slipped-down beds towards the scarp is also entirely against trough-faulting of the gulf; for if the beds ever extended far seawards with anything like the same dip, they would have attained a height much greater than that of the main plateau. The conclusion seems justified, therefore, that the faulting along the shore of the gulf is purely land-slipping, and has nothing to do with the main tectonics of the gulf. In other words, the Gulf of Suez, like the Wadi Araba, is not a trough-fault, but an eroded anticline.

[1] *Topography and Geology of the Peninsula of Sinai (Western Portion)*, Cairo, 1907, p. 30.

It will of course be remarked that an immense amount of erosion must have gone on in the gulf to remove the folded-up strata, while the trough-fault theory would not demand this. But one has to remember that in the case of the Wadi Araba there can be no doubt of erosion on this immense scale having taken place; for it is impossible to doubt the original continuity of the Eocene over the Wadi Araba, and the Carboniferous beds in the wadi-floor show that the Eocene has not been faulted down, so that it must have been eroded out. Vast ages must have been occupied in this erosion, even if it took place *pari passu* with the folding of the anticline. But with the greater space of time which physicists now allow us for the earth's evolution since the discovery of radio-active minerals, geologists will not feel that the time demanded for the erosion is any obstacle to believing it to have taken place.

The conviction that the Gulf of Suez is an eroded anticline and not a trough fault at once removes an important support from the 'rift theory' of the Nile Valley. For both the Nile Valley and the Gulf of Suez have on this theory been regarded as due to earth-movements of similar type acting about the same time, and if we show the movements postulated to have been non-existent in the one case, a doubt at once arises about the other.

I have made a search through the various publications to find out the history of the 'rift theory' as applied to the Nile Valley and the evidence relied on for its support. The earliest reference published appears to be in a paper read by my friend and former colleague Mr. Beadnell at the International Geological Congress at Paris in 1900, an abstract of which appeared in the Geological Magazine of January, 1901 (p. 23). Though Mr. Beadnell informs me that he no longer considers the trough-faulting of the Nile Valley to be a necessary conclusion from his observations, he has set out so clearly in his paper the only grounds on which the 'rift theory' rests, that it is advisable to quote them here as affording a definite basis for discussion. The facts which led Mr. Beadnell to the view that the Nile Valley had its origin in earth-movements and was not the result of erosion are as follows:—

(1) The general north and south direction of the Nile Valley in Egypt.

(2) The remarkable high, lofty, wall-like cliffs by which it is hemmed in.

(3) The absence of any true river-deposits at any considerable height above the river.

(4) The almost entire absence of hills or outliers of the plateau within the valley.

(5) The proved existence of bounding faults throughout a long stretch of the valley.

The whole weight of the evidence lies in the last fact given, the first four having but little significance in themselves. As regards the general direction of the valley, it is by no means straight; the greater part of it is approximately parallel with the Gulf of Suez, but if that gulf is not a trough there is no argument by analogy of direction.

The nature of the cliffs is no more evidence of faulting here than in the case of the Grand Cañon of Colorado. Moreover, cliffs of the same character occur in many lateral valleys, and any argument as to the one applies equally to the other; this difficulty was clearly perceived by Dr. Blanckenhorn,[1] who in accepting the trough-fault theory for the valley ascribed the origin of many of the lateral wadies to faulting. The absence of high river-terraces is easily explained by the frequent landslips at the face of the scarp and the action of the sand-blast through long ages. Outliers of the plateau within the valley would necessarily be infrequent on a theory of river-erosion without faulting. As to the bounding faults, there is no doubt whatever of the accuracy of Messrs. Barron and Beadnell's observations of the facts. I have seen many of the places myself and confirmed their sections. But one may dissent from their interpretation. The faulting observed is by no means continuous; it is most pronounced where soft, shaly beds have formed the base of the main scarp; no observation has ever been made of faulted-down rocks far from the scarps; and the faulted-down portions are exactly similar to those which occur in the oases, in the Wadi Araba, and along the coast of the Gulf of Suez, wherever there is an exposed face of a great plateau without any suggestion of trough-faulting. The true interpretation of the bounding faults of the valley is that they are landslips, and have nothing to do with the primitive formation of the valley. The valley was eroded first, and the landslips occurred afterwards. Faults or lines of weakness may have influenced the path of the river in its early stages, but the material which formerly extended from cliff to cliff has been removed seawards by erosion, not let down under the present Nile-bed. The great eastern wadies were formed contemporaneously with the Nile Valley by the same process of erosion, being the paths of tributary streams. They are on a scale quite comparable with the main valley, and there is no evidence whatever to support the view expressed by Captain Lyons that they originated after the main valley was formed. That the Nile Valley is geologically young is undoubted, but I know of no facts which would support the belief that it is of insufficient age for it to have been entirely excavated by erosion.

After coming to the above conclusion, I have had the pleasure of discussing the matter with Mr. Beadnell, who informed me that he has for some time abandoned the trough-fault interpretation of his observations, and he authorizes me to state that he has lately convinced himself that all the faults along the scarps of the Nile Valley can be explained as landslips, the harder limestones having slipped down over the softer underlying shales which have been eroded by the river.

Conclusions.

(1) The hypothesis that the Nile Valley and the Gulf of Suez owe their origin to trough-faulting is unwarranted by geological evidence.

(2) The Gulf of Suez is an eroded anticline.

(3) The Nile Valley is essentially a valley of erosion, and the

[1] "Geschichte des Nilstroms": Zeits. für Erdkunde, Berlin, 1902.

eastern wadies draining into it were formed contemporaneously, also by erosion.

(4) The faulting, which can be observed along the faces of the bounding scarps of the Nile Valley, Gulf of Suez, and the eastern wadies, is the result of landslips subsequent to the erosion of the hollows.

V.—Notes on new or imperfectly known Chalk Polyzoa.

By R. M. Brydone, F.G.S.

(PLATE VIII.)

(Continued from the January Number.)

Membranipora invigilata, nov. Pl. VIII, Figs. 1 and 2.

Zoarium adherent.

Zoœcia roughly elliptical, length ·60 to ·68 mm., width ·36 to ·40 mm., length of area ·36 to ·40 mm., width ·24 to ·28 mm.; they have broad side walls, whose upper surfaces slope slightly to the area; at the foot there is generally a fair amount of external front wall, which often carries its own accessory avicularium or the oœcium of the preceding zoœcium; the walls of adjacent zoœcia are always distinguishable and very often not in contact.

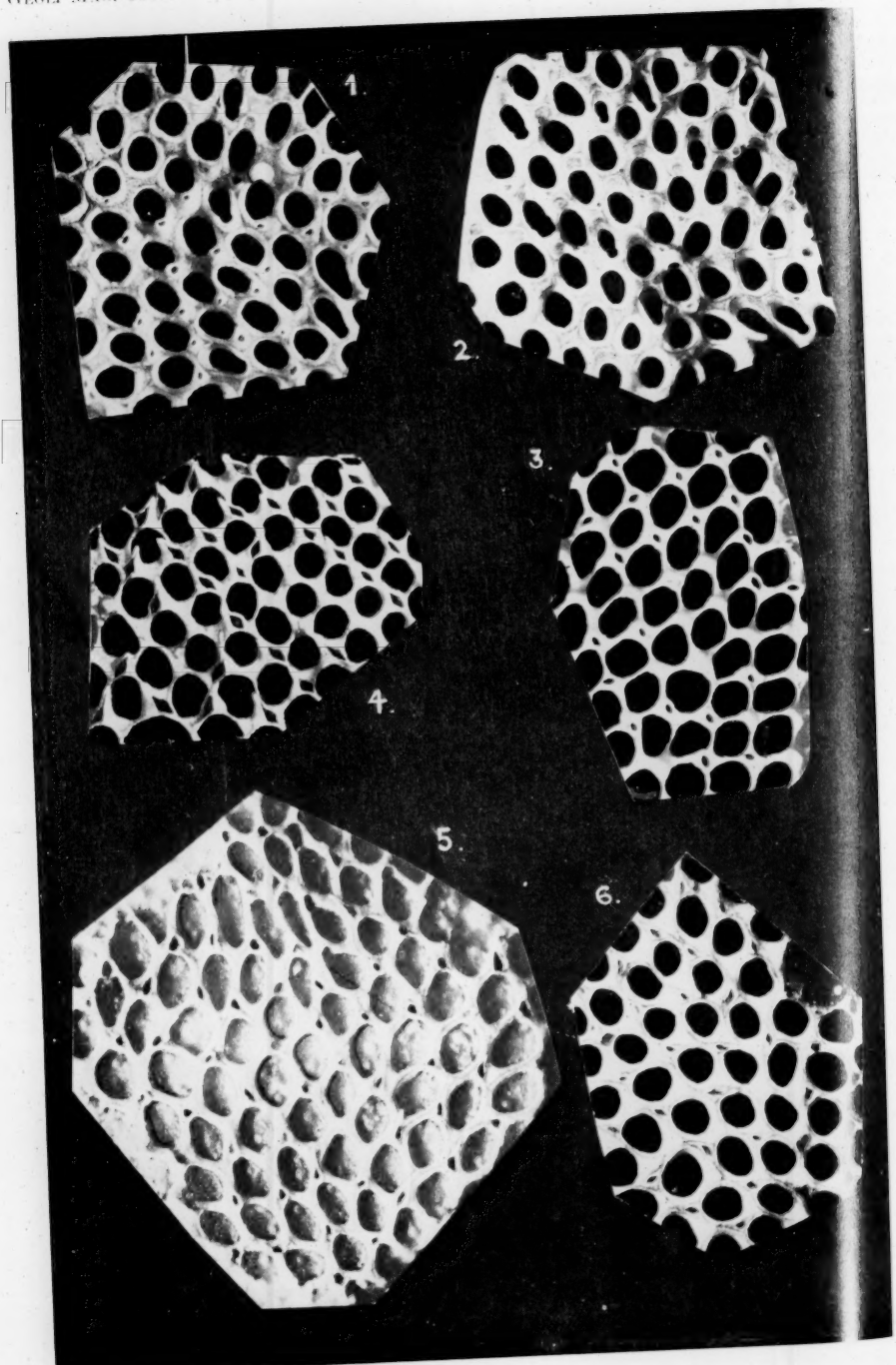
Oœcia abundant but very rarely preserved, globose, with a small part of the under edge free.

Avicularia of two types. (*a*) Accessory: these are small semi-circular tubular prominences developed on a semi-elliptical platform pushed out over the external front wall below the level of the rims of the area; they are directed forwards, looking over the area and sometimes overhanging it; sometimes the platform is formed without any further development, except perhaps a perforation. (*b*) Vicarious: these are long and narrow, widest at the head and tapering gently to the foot; aperture similar in outline, but with a construction of very variable degree near the foot, and bounded at the head by a broad internal shelf at some depth, which tapers rapidly towards the middle, where it disappears; at this point the bounding walls are folded over so that the outer edge in the upper part becomes the inner edge in the lower (well shown by the avicularium, which in Fig. 1 is immediately to the left of the only oœcium preserved).

Fairly common at Trimingham and in the zone of *Micraster cor-anguinum* at Gravesend, and I have found what may be a spinose stage of it in the zone of *Actinocamax quadratus*. *M. trigonopora*, Marss., has a general resemblance to this species, but has no vicarious avicularia, while this species has not the tiny pores of *M. trigonopora*.

Membranipora Britannica, mihi. Pl. VIII, Figs. 3 and 4.

I take this opportunity of giving photographs of the type-specimen (Fig. 3), and another with finely developed avicularia (Fig. 4). In a *Membranipora* so abundant almost any micrometric measure can be obtained, but ·36 to ·48 mm. for length of area and ·28 to ·32 mm. for



R. M. Brydone photo. Chalk Polyzoa.

width of area seem fairly representative. The specimen shown in Fig. 4, though very exceptional in its large and graceful avicularia, quite 99 per cent. of specimens conforming closely with the type, raises an interesting question whether Fig. 3 ought to be regarded as the true standard and Fig. 4 as a sport, or whether Fig. 4 ought to be regarded as the true standard and Fig. 3 as due to mechanical causes—attrition and solution—or to the general prevalence of some local condition unfavourable to a full development of the avicularia. As the two specimens grew contemporaneously and under identical conditions, so far as can now be judged, the question is more acute than in such a case as *Cribrilina Gregoryi*, where the avicularia are mere rings until we get high up in the zone of *Act. quadratus*, where they become mandibular.

Membranipora Britannica, var. præcursor, nov. Pl. VIII, Fig. 5.

This is the form which occurs in the Upper Senonian, especially in the zones of *Act. quadratus* and *Belemnitella mucronata*. The zoœcia are distinctly shallower, longer, and wider than in the type, the walls of adjacent cells are practically always distinguishable, and the avicularia lie practically on their backs and along the surface of the zoarium and with their long axes nearly parallel to those of the zoœcia. The oœcia are so fragile that I have not yet seen one preserved. Length of area ·48 to ·64 mm., width ·36 to ·40 mm.

Membranipora Britannica, var. demissa, nov. Pl. VIII, Fig. 6.

This form occurs not unfrequently at Trimingham. It is intermediate between the type and the var. *præcursor* in that its avicularia lie along the surface of the zoarium, with their long axes nearly parallel to those of the zoœcia, but distinctly on their sides. It is clearly distinguished from both by its pyriform zoœcia with considerable extent of front wall. The type does, it is true, often show a local tendency towards a pyriform zoœcium with front wall, but this always appears to be due either to crowding, which forced the zoœcium to grow some distance before it could open out its area, or to the failure of the preceding zoœcium to produce an avicularium or an oœcium to occupy the space provided for it; the tendency does not go farther than may be seen here and there in Fig. 4. In the var. *demissa* the pyriform shape is obviously a fundamental character (which might be held to justify a specific separation), and is developed concurrently with the provision for the avicularium of the preceding zoœcium. Besides these specific points of difference there is a considerable difference in matters of degree which is incapable of any exact definition, but which makes the variety readily recognizable with a pocket magnifier. Length of area ·36 mm., width ·32 mm.

EXPLANATION OF PLATE VIII.

Fig. 1. *Membranipora invigilata*. Chalk of Trimingham. × 20.
,, 2. Ditto, another specimen. Ditto. × 20.
,, 3. *Membranipora Britannica*, type-specimen. Ditto. × 20.
,, 4. Ditto, another specimen. Ditto. × 20.
,, 5. Ditto, var. *præcursor*. Zone of *Actinocamax quadratus*, Winchester. × 20.
,, 6. Ditto, var. *demissa*. Chalk of Trimingham. × 20.

VI.—On the Discovery of *Archæosigillaria Vanuxemi* (Göppert) at Meathop Fell, Westmorland, with a Description of the Locality.

By J. Wilfrid Jackson, F.G.S., Assistant Keeper of the Manchester Museum.

In September last I discovered a number of plant remains in the Carboniferous Limestone at Meathop Fell, Westmorland, amongst which were several fragments of what, at first sight, looked like a species of *Lepidodendron*. A closer examination, however, of one or two of the better preserved specimens, which showed traces of leaf-scars, at once suggested *Archæosigillaria Vanuxemi*, specimens of which I had previously seen in the Kendal Museum.

On a later visit to Meathop Fell I was successful in obtaining a number of other fragmentary specimens of the same plant, along with a specimen of a cone, which from its position and association with branches of *A. Vanuxemi*, has every appearance of belonging to that species. Unfortunately the branch bearing it is so badly preserved that no definite details can be made out, hence there is no conclusive proof that it belongs to the above species. This is all the more unfortunate, as, up to the present, the fructification of this interesting plant is unknown.

The majority of the plant-remains found appear to be referable to the above species, but one or two specimens occurred which looked like the flattened stems of other plants. The identification of these, however, is impossible, owing to their badly preserved condition. I also obtained a portion of the stem of *Bothrodendron* sp., which will be referred to later.

The present discovery of *A. Vanuxemi* constitutes the third recorded occurrence of the species in Britain. The first British specimens, which are in the Kendal Museum, were brought to the notice of Dr. Kidston by Mr. R. Bullen Newton, F.G.S., and were described in 1885 as *Lycopodites* (*Sigillaria*) *Vanuxemi*.[1] These specimens were collected from the lower beds of the Mountain Limestone, near Shap Toll-bar, Westmorland. In 1899 Dr. Kidston created the new genus, *Archæosigillaria*, for the reception of this plant.[2]

The second discovery was made near Dyserth, North Wales, by Dr. Wheelton Hind, F.R.C.S., etc., and Mr. J. T. Stobbs, F.G.S.[3] Here the species was fairly common, and was associated with a fauna characteristic of S_2.

It may be of interest here to call attention to the fact that the type of the species was discovered in the Upper Devonian (Chemung Group) of New York, but all the British examples originate from a higher horizon.[4]

Description of the Meathop Specimens.

Archæosigillaria Vanuxemi (Göppert).

The largest specimen I obtained measures 18 cm. in length, the width of the branches being from 8 to 10 mm. It exhibits very clearly the dichotomous branching of the species, but owing to the branches being flattened by pressure and rather badly

[1] Journ. Linn. Soc., Botany, vol. xxi, p. 560, pl. xviii.
[2] Trans. Nat. Hist. Soc. Glasgow, N.S., vol. vi, p. 38.
[3] Geol. Mag., 1906, p. 391, and Rep. Brit. Assoc. for 1906, p. 303.
[4] Journ. Linn. Soc., Botany, vol. xxi, p. 565.

preserved, the leaf-scars are not shown to advantage. The slab containing this specimen also shows a cross section of a species of *Syringopora*, and contains several specimens of *Seminula* sp. On the back of the slab is a portion of a branch bearing the cone referred to previously, and I found on development that the branch continued through the stone to the other side, where faint traces of it were visible a little to one side of the branches just described. The cone appears in section, the separation of the slab having passed through its central axis. Both halves exhibit very clearly a long peduncle coming off at right angles to the stem. This is clothed with acicular bracts for a distance of three-quarters of an inch, where traces of sporophylls, ending in long points, begin to appear. The cone has a width of about half an inch, and measures $2\frac{1}{4}$ inches in length, including the peduncle, but has undoubtedly been much longer, as the top portion is missing. Owing to its bad state of preservation, no further details can be made out with certainty.

On another fragment of limestone, a portion of a dichotomously divided stem occurs, which exhibits, fairly well, the characteristic hexagonal leaf-scars of the older branches of *A. Vanuxemi*. These scars are rather longer than broad, and measure 4·5 mm. by 3 mm., the width of the stem being 9 mm. No vascular cicatricule, however, can be made out.

Bothrodendron sp.

This consists of a flattened portion of a large stem, which has come out free from the matrix. It measures $5\frac{1}{2}$ inches in length, $2\frac{1}{2}$ to 3 inches in breadth, and is 2 inches in thickness. The surface is a mere film of carbonaceous matter, on which leaf-scars are distinctly visible in several places. These scars are 7 mm. apart, disposed in rows 10 mm. apart, each row winding round the stem in the usual rapidly ascending manner. The specimen is too badly preserved to be specifically identified.

Topography and Geology of Meathop Fell.

Meathop Fell, which lies about a mile and a half east of Grange-over-Sands, is an isolated exposure of Carboniferous Limestone, surrounded on all sides by alluvial flats and salt-marsh. It is a little more than a mile in length, and just over half a mile in breadth; its greatest height above sea-level is 179 feet. On its south-east side it is cut off, by the Kent Estuary, from the Arnside Beds, which come next in succession. The exposure may be described as being made up of a series of beds of impure limestone, more or less dolomitic, separated at intervals by thin earthy bands. The limestone is extremely hard, compact in texture, and breaks with a conchoidal fracture. It has been much quarried for strong plain work, such as engine beds, foundations, etc., but is not suitable for sculpture. The general dip of the beds is at a very low angle, it being about 8° S.E.

Fossils are not numerous in species, but large masses of *Syringopora*, along with a few small Cyathophyllids, etc., occur weathered out in relief on the cliff face, especially at Meathop Fell end. The *Syringopora* appear to consist of two forms; in one case the corallites are very small, not more than $\frac{1}{16}$ of an inch in diameter, geniculated, and with fairly numerous connectors; in the other case the corallites are distinctly larger, closely set, and possess a thick wrinkled epitheca; connectors fairly numerous, walls of corallites rather thick; diameter about 1 line. This form agrees very closely with *S. geniculata* of Edwards & Haime's figs. 2 and 2*a* of plate xlvi.[1]

Near the top of the Fell, an impure limestone band, several inches thick, occurs, which appears to be entirely made up of specimens

[1] *A Monograph of the British Fossil Corals*, 1852 (Pal. Soc.).

of *Seminula* sp. (cf. *ficoidea*), nearly all of which have the two valves adherent. Many of the specimens, however, are much crushed and broken. Occasional examples of single valves may be found which exhibit their Athyrid characters remarkably well. On the weathered faces of this bed, very definite lines of stratification may be observed, alternating between the layers of shells. The only other species, so far, noticed in this band is a small fragment of an *Athyris* showing concentric lamellation. There is a possibility of some of the others being *Athyris* also, which have lost their outer layer and therefore resemble *Seminula*. In its general appearance this band bears a striking resemblance to a modern sea-beach, where shells are thrown up in hundreds; and it may, in all probability, represent an old shore-line. The same form of *Seminula* also occurs scattered through the beds below the above-mentioned band.

At the top of the Fell, at the Meathop Fell end, I obtained the following species: *Spirifer* cf. *furcatus*, M'Coy[1] (abundant), *Reticularia* aff. *lineata* (Martin) (rare), and one or two others too imperfect to identify with safety. Other species collected at various parts of the Fell are, *Psammodus rugosus*, Ag. (fragment of tooth), *Euomphalus* sp. (cast), *Fenestella* sp., *Seminula* (? *ambigua*), and *Productus* aff. *corrugatus*, M'Coy.

The plant bed is apparently not exposed at the southern end of the Fell, as I have never seen any traces of it here. Where it does crop out is some little distance to the north. Associated with the plant remains are some small Seminulas and a *Syringopora* of a small ramulose type, which does not appear to have received a name yet. In beds immediately above, masses of *Syringopora* occur in abundance, and where these beds crop out at the surface large specimens may be obtained beautifully weathered out and free from matrix. With regard to the species of *Syringopora*, Dr. Sibly, to whom I submitted specimens, has no hesitation in calling it a small variety of *S. geniculata*, using that name merely as a group name, and adopting Edwards & Haime's interpretation of the name. He says it is distinctly smaller than the *S.* cf. *geniculata* which abounds in D_1 of the South-West and the Midlands, but is of the same type.

It is perhaps premature to attempt to fix definitely the exact horizon of these beds, as they appear to have been, as yet, but superficially studied.

As already mentioned in the North Wales exposure, *A. Vanuxemi* occurs in beds which are assigned to the S_2 subzone. In the Shap exposure, the exact horizon and fossil associates of *A. Vanuxemi* are, unfortunately, not so well known. My friend Canon Crewdson, honorary curator of the Kendal Museum, tells me that the Shap Toll-bar quarry (now closed), from which their specimens came, is about 1½ miles south of the village. He has since found the species in an old quarry at the northern end of the village, but cannot remember seeing any other fossils associated with it. In his opinion the 'Vanuxemi Bed' forms part of the Shap–Ravenstonedale Limestone, probably near the top. He has, however, seen no trace of *A. Vanuxemi*

[1] This and several others were kindly identified by Dr. T. F. Sibly, F.G.S.

in the quarry at Shap summit, near the Granite works, which is said to be the same Limestone, though there are frequent vegetable remains (*Stigmaria*, etc.) in that quarry.

Professor Garwood, in his provisional correlation of the Faunal Succession in the Carboniferous Limestone of these Northern exposures,[1] places the Meathop Fell Beds doubtfully in C_1, and correlates them with similar dolomitic beds at Crag Mollet in the Brigsteer section. At the latter place a bed occurs at the base which is marked by clusters of *Diphyphyllum pseudo-vermiculare* (M'Coy). This same form also occurs abundantly near the top of the Shap–Ravenstonedale Limestone, so that the beds containing *A. Vanuxemi* at Shap are, in all probability, equivalent to the 'Vanuxemi Beds' at Meathop Fell.

Professor Garwood further remarks on the possibility of the above Diphyphyllid *Lithostrotion* being considered typical of (S), in which case the Meathop Fell Beds, and others, would have to be included in (S) also.

The discovery, therefore, of *A. Vanuxemi* at Meathop Fell, coupled with its occurrence in beds of, presumably, the same age at Shap, may be helpful in arriving at a satisfactory conclusion as to the correct horizon of these beds, especially when the exact horizon of the plant is known in the North Wales exposure.

In conclusion, I must express my indebtedness to Mr. J. T. Stobbs, F.G.S., and Dr. T. F. Sibly, F.G.S., etc., for their kindness in confirming the identification of several specimens, and to Dr. R. Kidston, F.R.S., etc., for kindly looking over the plant-remains and giving me his opinion thereon.

NOTICES OF MEMOIRS.

Note on the Spontaneous Luminosity of a Uranium Mineral.[2]

By the Hon. R. J. Strutt, M.A., F.R.S., Professor of Physics, Imperial College of Science, South Kensington.

Rumours of luminosity having been observed in Cornish minerals, in the dark, are not infrequent. I have myself been told of such phenomena by rustics in the mining district, and more than one correspondent has mentioned something similar.

Mr. F. W. Rudler[3] has quoted a remark by the late Mr. Garby that specimens of uranite "when first discovered by the miners in Huel Buller and Huel Basset were very phosphorescent, so much so that after the lights were extinguished many of the crystals might be discovered in situ",[4] and he has suggested that this may be in some way connected with the self-luminosity of radio-active bodies. The observation would seem to have been made by the miners, not by a scientific observer, and it is implied that the luminosity was of the nature of ordinary phosphorescence, and due to previous exposure to light.

[1] Geol. Mag., 1907, p. 70.

[2] Proc. Roy. Soc., Series A, 1909, vol. lxxxiii, p. 70. (Abridged.

[3] *Handbook to Minerals of the British Islands*, published by the Geological Survey.

[4] Trans. Roy. Geol. Soc. Cornwall, 1865, vol. vii, p. 86.

Recently examining a specimen of uranite (autunite), I was struck by its resemblance to the artificially prepared uranium salts, and it occurred to me that in all probability it would be found to exhibit the spontaneous luminosity observed in these by H. Becquerel,[1] which is attributable to fluorescence of the substance under the action of its own radio-activity. Experiment confirmed this anticipation. The mineral is easily perceived in a perfectly dark room by a well-rested eye. There is no difficulty in walking up to it from a distance and touching it, without any other guidance than the luminosity. Autunite is more luminous than uranium nitrate, but less so than potassium uranyl sulphate.

This effect is quite independent of the previous exposure to light. Such exposure only leaves an afterglow in uranium salts of very short duration. It cannot be detected without the phosphoroscope.

The specimens in which I have observed the luminosity are some recently raised in Portugal, which I owe to the kindness of Mr. A. de Vere Hunt. Old specimens from Cornwall and from Autun do not exhibit it. The loss of luminosity is connected with a loss of water of crystallization. This was established experimentally by sealing up a specimen in an exhausted glass tube with phosphoric anhydride. In a few hours the latter had deliquesced considerably, while the autunite had lost both its luminosity in the dark, and also the green fluorescent shimmer which it had previously exhibited in daylight. Some uranium salts are known to be much more fluorescent than others, and there is nothing specially surprising in the fact that a loss of water is accompanied by a loss of brilliancy.

REVIEWS.

I.—Geological Survey of Great Britain.

The Geology of the Country around Basingstoke. By H. J. Osborne White, F.G.S. pp. v, 119, with 14 text-illustrations. 1909. Price 2*s*. Colour-printed map, Sheet 284, 1*s*. 6*d*.

ALTHOUGH not officially connected with the Geological Survey, Mr. Osborne White has already rendered much service to the Institution in writing the Memoir on the Geology of Hungerford and Newbury, and in assisting with those on Andover, Henley-on-Thames, and Wallingford. He has now written the memoir to accompany Sheet 284 of the new series Geological Survey Map, which embraces an area concerning which we have hitherto had very little detailed information beyond that contained in previous official memoirs on more extensive tracts, by H. W. Bristow, W. Whitaker, and A. J. Jukes-Browne. The six-inch field-maps, showing the revised geology, with notes by the late J. H. Blake and Messrs. C. E. Hawkins and F. J. Bennett, were placed at the service of the author.

The country under consideration is almost wholly in Hampshire, the northern part including a tract of the Eocene strata of the London Basin; and the southern part consisting mainly of Chalk with a portion

[1] *Comptes Rendus*, 1904, vol. 138, p. 184.

of the Upper Greensand inlier of Kingsclere on the west, and a portion of the Wealden area on the south-east. This latter tract, drained by the head-waters of the Wey, takes in less than a square mile of the parish of Farnham in Surrey.

The lowest formation exposed is the Gault, and the Folkestone Beds of the Lower Greensand have probably been reached in a well in the Wey Valley. The Gault, no doubt, underlies the whole of the area, but nothing is known of the underground disposition of the strata beneath, nor of the depth to the Palæozoic floor.

Particulars are given of the Gault, with the zone of *Douvilleiceras mammillatum* at its base, and that of *Hoplites interruptus* above; and also of its fossils and phosphatic nodules. The Upper Greensand, consisting largely of malmstone, siliceous and calcareous, belongs to the zone of *Schloenbachia rostrata*, and the highest beds adjoining the Chloritic Marl are locally impregnated with phosphatic matter. The phosphatic beds at the base of the Chalk, which contribute so much to the fertility of the soil on the Chloritic Marl, were described more than sixty years ago by Paine & Way, but the pits which yielded many fossils in the parishes of Bentley and Farnham have long been filled up and obliterated. The Chalk divisions range from the zone of *Schloenbachia varians* to that of *Marsupites testudinarius*, and much new information is given regarding the strata and their fossils, including the sub-zone of *Heteroceras reussianum* and the *Uintacrinus* Band.

Despite the great unconformity between Chalk and Reading Beds no evidence of discordance has been observed in the district. The surface of the Chalk was even where the junction of the formations could be seen, but in two localities the perforations of some boring animal were seen on the Chalk floor. The author assigns to the Reading Beds the blocks of greywether sandstone which occur here and there in the district.

The London Clay, which extends over a considerable area, has yielded a good many fossils, and it attains a thickness of 335 feet near Odiham. The author remarks that it is probably not more than half that thickness in the north-western part of the district. Westwards, in the Andover country, the thickness of the London Clay has been estimated at from 60 to 100 feet, while south of Newbury it is about 60 feet, and thence it diminishes further west and to the north.

The Bagshot Series is described under the headings of Lower Bagshot Beds, Bracklesham Beds, and Upper Bagshot Beds—perhaps because this classification was adopted on the colour-printed map which, though issued in 1905, was based on the hand-coloured map of 1897. The grouping, therefore, differs from that adopted in the Andover Memoir of 1908, wherein the term Bagshot Beds is restricted to the Lower Bagshot Beds. The Upper Bagshot Sands of the London Basin are now usually grouped with the Barton Beds.

There is an interesting chapter on the tectonic structure and drainage features, illustrated by a map showing the lines of anticline and syncline, while the author points out the relations of the streams to the geological structure.

The Plateau gravels are regarded as of fluviatile origin, and as "remnants of old alluvial flats or flood-plains, developed during

pauses in the downward displacement of the local limit of subaerial degradation".

The Clay-with-flints, the Valley gravels, and Alluvial deposits are duly described, and there is an excellent chapter on Economic Geology.

The Memoir throughout bears evidence of much diligent research, and adds largely to our knowledge. The author, moreover, has carefully studied the works of other geologists, and does full justice to their labours. The only misprint we notice is H. W. Fitton for W. H. Fitton.

II.—The Geology of the Country around Bodmin and St. Austell. By W. A. E. Ussher, G. Barrow, and D. A. MacAlister, with Notes on the Petrology of the Igneous Rocks by Dr. J. S. Flett. 8vo; pp. vi, 201, with 3 plates and 34 text-illustrations. London, 1909. Price 4*s*.

THIS Memoir is descriptive of the one-inch colour-printed map Sheet 347, which takes in the area from Bodmin on the north to the coast at Fowey and St. Austell Bay on the south. The greater portion of this country is occupied by Lower Devonian rocks and the bold granite mass of St. Austell and Hensbarrow, with a tract of Middle Devonian slates on the north-east. The oldest Devonian rocks, grouped as Dartmouth Slates, contain fish-remains of Lower Old Red Sandstone type, and the rocks appear in an anticline along the eastern coast to the north of Fowey, and thence extend to near Lostwithiel. They are bordered by the Meadfoot Beds, beyond which are the Staddon and Grampound Grits. The coloration of the map suggests that the Staddon Grit on the north and the Grampound Grit on the south are equivalent strata on the opposite sides of the anticline. This view is supported by Mr. C. Reid, but is not accepted by Mr. Ussher, who regards the Grampound Grit Series as representing the marginal conditions of lower beds in the Meadfoot Group, perhaps equivalent to the Looe Grits. The Meadfoot Beds have yielded a number of fossils, but so poorly preserved that most of the species and many of the genera collected by the Geological Survey are doubtfully identified. Fossils throw no light on the disputed succession, as none are recorded from the Grampound or Staddon Grits.

The Middle Devonian slates are stated to be fossiliferous, though "it is very seldom that anything but crinoid markings can be distinguished".

The region therefrom is not one to attract the student of Devonian palæontology; but a great step in advance over the older map has been made in the insertion of the geological subdivisions now depicted, while the long experience gained by Mr. Ussher has enabled him to correlate them with the subdivisions which he has traced step by step from Eastern Devonshire.

The granite areas have been mapped out in much more detail than in the original geological survey map, and the metamorphic aureole in the bordering Devonian rocks, described mainly by Mr. Barrow and Dr. Flett, has been more definitely indicated. Dr. Flett has dealt generally with the pneumatolytic alteration of the granite, observing that the changes produced by vapours passing through the rock, after

its consolidation, are of three sorts: (1) tourmalinization, as exemplified in luxulyanite and in the schorl-rock of Roche; (2) greisening, as seen at Criggan; and (3) kaolinization. The kaolinization or alteration of granite to china-stone and china-clay is a subject discussed by Mr. MacAlister, supplemented by observations made by Dr. Flett. With regard to the kaolinization, Mr. MacAlister refers to the agency of magmatic waters containing carbon dioxide in solution and fluoride vapours. Dr. Flett remarks that the facts "point to the probability that neither fluoric nor boric gases were the chief agencies of kaolinisation, and support Vogt's hypothesis that carbonic acid was the principal, though probably not the only, gas involved". Many interesting particulars are given of the china stone and china-clay, but it has not been found possible to mark on the map the areas over which they are exposed. Economic geology, indeed, receives ample treatment. The chapter on mining, prepared by Mr. MacAlister, with numerous illustrative sections, contains full information of the workings for tin and copper ores, as well as silver-lead ores, red and brown hæmatites (for which Restormel was once famous), manganese ore, gold, uranium ore, etc. Of road-metals, the harder dhabases and the calc-flintas (altered calcareous sediments in the Meadfoot Beds) are reckoned more durable than the elvans.

Mr. Barrow has described some of the physical features and the indications he has found of the old Pliocene platform at about 430 feet above sea-level. There on flat moors, beneath peat, rainwash, and head, occur ferruginous gravels that have been worked for stream-tin, and these may possibly be of Pliocene age. The later Pleistocene and Recent deposits are described in detail, evidently by Mr. Ussher, but curiously enough his initials, appended to many paragraphs, have been omitted from this section as well as from the important chapters on the Devonian rocks. This is much to be regretted.

III.—The German South Polar Expedition, 1901–1903. Vol. II, Heft V: Geography and Geology. pp. 63 and 3 plates. Berlin, 1909. Price 10 marks (8 marks to subscribers).

(Deutsche Südpolar-expedition, 1901–1903, im Auftrage des Innern herausgegeben von E. von Drygalski, Leiter der Expedition. II Bd. Geographie und Geologie, Heft V.)

THE present report is composed of four sections, dealing mainly with the islands of St. Paul and New Amsterdam in the Indian Ocean. The geography is dealt with by E. von Drygalski, the leader of the expedition, the geology by E. Philippi, the character of the rocks by R. Reinisch, and the plants and animals by E. Vanhöffen. According to Dr. von Drygalski, the islands of St. Paul and New Amsterdam are both volcanic and rest upon a common tapering base, which rises from about 3000 metres below sea-level. At a depth of 1500 metres this common source divides into two cones, which form the two islands. Both islands have a number of parasitic cones, but these do not constitute so striking a feature in the case of St. Paul as in New Amsterdam. The islands of Kerguelen and Heard on the one hand, and St. Paul and New Amsterdam on the other, also have a common

base, which rises above the surrounding Kerguelen Plateau. When St. Paul, in particular, is considered it is found that the inner part of the crater is connected with the outer sea by reason of the submergence of the north-easterly part of the island along a S.E.–N.W. line. The salinity of the water within the crater basin is almost identical with that of the surrounding sea, while within the crater itself this salt-percentage, as well as the temperature of the water, remains constant for the whole depth. According to Vélain, a former explorer, the amount of carbon dioxide in the crater water increases with the depth. He derives the gas from the exhalation of CO_2 and N from the ground of the basin. Such an exhalation would also materially affect the distribution of the organic life. Former investigators have reported that the water temperature at the margin of the basin locally exceeded that of the inner portion by 4° or 5°, but this has been found by the present explorers to be not the case. Practically the same temperature prevails on the margin as in the middle. From this, as well as from other evidence of a negative kind, the absence of hot springs might be inferred. As the distance apart of the positions where the temperatures were taken is, however, about 400 metres, the existence of such springs is not an impossibility. Both islands have very steep coasts, the coast being highest on the west, where, on account of the stronger westerly winds, the wave action is heaviest. The deepest parasitic craters of St. Paul are on the south and west cape. They are already partly cut through by the sea, as shown by the charts of Vélain and von Hochstetter. Such a phenomenon shows the great influence of the wave action, since the chief crater itself, according to von Hochstetter, is not very old, and the parasitic craters are quite young. In view of the morphological and climatic conditions the only possibility of anchoring for the purpose of landing on either of the two islands is on the north-east side. It appears that human habitation would suffer from the poor water supply, and St. Paul, in particular, would be less advantageous, because of the absence of wood. An attempt was made, through a previous expedition (that of the "Novara"), to start wood-growing, but the result has been disappointing. The fishermen have successfully grown potatoes, wheat, maize, and barley, and other grain also appear to grow well. Both islands might thus be possibly used as settlements, yet the unfavourable climate and the absence of firewood would be great hindrances. The chief value of the islands lies in their wealth in fish.

In the geological section Dr. Philippi gives, as in the foregoing section, an historical account of the works of previous investigators as far as they bore on geology. Among these writers Vélain and von Hochstetter are to be particularly mentioned. Dr. Philippi differs from the older explorers in regard to the last period of eruption and the origin of the present crater of St. Paul. In agreement with von Hochstetter, he would consider the crater-opening to have been formerly much smaller and higher than the present central crater; but Dr. Philippi thinks that this older vanished central crater of the basaltic period did not lie at the middle, but near the margin of the present crater basin. Although, as stated by von Hochstetter, the present crater is a product of a very late time, and was certainly

not in existence in its present form during the basaltic eruptive period, yet it is believed that the shape of the present crater is to be explained through an explosive outburst rather than subsidence. As regards the lavas and tuffs of St. Paul, it is impossible to speak of the period of their origin with certainty, because of the absence of any fossil-bearing sediments. Probably a part of the eruptive period belongs to Tertiary, another to Quaternary and later times. It is impossible, however, to know where the Tertiary portion ends and the other begins. An examination of the Dumas crater of New Amsterdam revealed evidences sufficient to support Vélain's results in all essential details. The crater cone and the lava streams which ran from it have quite a fresh appearance; the eruptions were undoubtedly still in progress during historical times. The late period of eruption of the lava streams accounts for the favourable landing facilities near the Dumas crater, for the wave action has not had time to cut a steep wall in the lava. Lateritic weathering products, which play such an important part on the island of St. Paul, are absent. This fact also speaks for the recency of eruption in the Dumas crater. In some parts of the lava, cavities, often 8 to 10 metres broad, twice the same measurement in height, and over 200 metres long, were met with. From the roofs of these caves hang lava stalactites of fantastic shapes. According to Vélain the cavities are due to gases which collected under the lava stream and afterwards forced their way through it. The present-day vulcanologist generally explains such a phenomenon as the result of the coating of the upper layer of the lava stream by a non-yielding outer crust; the inner portion of the stream, moving forwards, would leave behind a hollow cavity. Some of the cavities observed by the present expedition were undoubtedly the result of gaseous accumulation.

Dr. Reinisch discusses the chemical relationship of the basalts of St. Paul, New Amsterdam, Kerguelen, Heard, and Possession Islands. Rhyolite tuff, basalts, and siliceous sinter are found on St. Paul; only basalts of various constitution are known on New Amsterdam, basalts, phonolite, and trachyte on Kerguelen, and basalts on Heard and Possession Islands. Very instructive tables and diagrammatic proportional representations of the chemical constituents of the rocks are given.

Dr. Vanhöffen treats of the plants and animals of St. Paul and New Amsterdam in an exhaustive manner. A comparison of the faunal lists of the two islands shows a certain agreement. This agreement would probably be found on closer investigation to be still greater than appears at present. It is also seen that the number of peculiar forms is few and that no close relationship exists with the animal life of the neighbouring sub-Antarctic islands. Hence it is inferred that the fauna is an accidental and not an original one, and that it has been affected by human interference.

The report is illustrated by three plates of eight photographic views and several text-illustrations.

Ivor Thomas.

IV.—Aids in Practical Geology. By Professor Grenville A. J. Cole. Sixth edition. 8vo: pp. xvi, 431, with 2 plates and 136 text-illustrations. London: Charles Griffin & Co., 1909. Price 10*s.* 6*d.*

THAT a geological handbook should pass through six editions in the course of eight years is the most satisfactory testimony to its merits, and we heartily congratulate the author on the well-deserved success of his work. The volume has remained of the same dimensions since we noticed the issue of the fourth edition in 1902, but it has undergone sundry revisions and alterations needful to bring the subject-matter up to date. As a companion and practical guide to geology the work is excellent. In the preliminary chapters the student will learn how to equip himself for field observations and the collection of specimens, while the main portions of the volume give precise and abundant information on the modes of examination and determination of minerals, and of rocks, sedimentary, igneous, and metamorphic. The final part deals with the examination of fossils, so far as the invertebrata are concerned, and the author has rightly endeavoured to keep the limits of the genera as wide as possible. Thus we are glad to see such a name as *Rhynchonella spinosa* perpetuated in place of the modern subdivisions of the genus, which are useful only to a palæo-zoologist.

V.—Transactions of the New Zealand Institute, vol. xli, for 1908, issued June, 1909.

IN an article on "The Geology of the Quartz Veins of the Otago Goldfields", Mr. A. M. Finlayson points out that these veins would suffice to account for the alluvial gold, and that no other source, such as had been suggested with reference to the schists, supplied any appreciable quantity.

Dr. P. Marshall describes a nephelinitoid phonolite from Rarotonga, and a similar rock has been found near Signal Hill, Dunedin, by Mr. C. A. Cotton, who gives an account of other varieties of phonolite from that district. Mr. R. Speight records the occurrence of a hornblende-andesite in the Solander Islands. Dr. Marshall describes some new species of fossil Cephalopods from strata in the neighbourhood of Mandeville and Kawhia Harbour. They include *Bronocceras*, *Orthoceras*, *Arcestes*, *Phylloceras*, and *Ægoceras*. Among other fossils are *Ostrea*, *Gryphæa*, *Trigonia*, *Halobia*, and *Spiriferina*. Dr. Marshall remarks: "Since several of these are not known in strata older than the Jurassic, it is probably right to class these strata as Jurassic, thereby ignoring the presence of the archaic genera here mentioned. This conclusion seems all the more reasonable when the present isolated position of the Dominion is considered. It is quite possible that another period of isolation had terminated at the beginning of the Jurassic period. An old fauna which had lived on during the period of isolation would then be mingled with the invading newer and more vigorous types. Such an explanation might reasonably account for the rapid change in life-forms which has caused Sir James Hector to class a conformable series of rocks as of an age extending from Permian to Jurassic."

VI.—Geological Survey of Western Australia.

BULLETIN No. 35 (1909) consists of a well-illustrated report on the Gold and Copper Deposits of the Phillips River Goldfield, by Mr. Harry P. Woodward, with notes on the crystalline rocks by Messrs. E. S. Simpson and L. Glauert. The district lies near the south coast, with a port about 150 miles east of Albany, and in geological structure it is a complex of schists and serpentines, granites and greenstones, together with some probably Tertiary sandstones, quartzites, and conglomerates, and various superficial deposits. The crystalline rocks are much decomposed, in places to a depth of nearly 100 feet, and the lodes, with few exceptions, have at present been worked only above the ground water-level. The lodes comprise (1) basic cupriferous dykes, and (2) siliceous and ferruginous deposits, which appear to fill channels along rock-joints. The conclusions drawn are that the cupriferous dykes are of sufficient size to warrant deep mining, but that gold and silver will then occur in negligible quantities. The siliceous and ferruginous deposits give less promise of permanency, but they usually carry fairly high gold and silver values, and have been classed as auriferous lodes, copper, when present, being in small quantities. In some instances, however, with increasing depth, the gold is greatly diminished, and copper ore becomes dominant. It is noted that primary sulphides occur in the rocks above the ground water-level, and the explanation given is that the great density and impermeable character of the matrix have protected the ore, in these cases, from the oxidizing influence of descending aerated water. The ores worked during the past eight years have yielded on an average 4 per cent. of copper and half an ounce to the ton of gold.

VII.—Schluchten auf dem Plateau Tschokusu. By Alexander Iwtschenko (of Kiev). [The Ravines of the Tschokusu Plateau.] Ann. géol. et minéral. de la Russie, Novo-Aleksandria, vol. xii. livr. i–ii, pp. 19–26.

THIS paper sets forth the results of the investigations carried out by the author during a second excursion to the southern portion of the Tschokusu Plateau in the summer of 1908. The district is cut out into terraces, the southern margins of which are broken into by ravines. These ravines widen considerably, and often form cauldron-shaped expansions in their upper reaches (*Oberläufe*), while the lower reaches become narrower. The terraces undoubtedly represent the results of the drying-up of the Aral basin. Their relative size and slope point to intermittent recession of the sea, the periods of non-recession corresponding to the time when the terraces were formed. The ravines were formed contemporaneously with the recession of the sea, the upper reaches having originated at an earlier period than the narrower lower reaches. From the nature of the denudation the Tschokusu Plateau belongs to the same category as the district of Barsukow; both are characterized by desert conditions.

The article is accompanied by three photographs and two diagrammatic illustrations.

I. T.

VIII.—A New Pocket-Guide to Chalk Fossils. Karl Wanderer. Die wichtigsten Tierversteinerungen aus der Kreide des Königreiches Sachsen. 8vo; pp. xxii, 80, with 12 plates in 4to (folded), and 11 figures in the text. Jena, 1909. Price 3 marks.

THE plan of this little book is excellent. It provides a tabular view of the Chalk of Saxony, a bibliography, a list of places where fossils can be obtained, and devotes its eighty pages to short descriptions of the fossils, commencing with the Foraminifera and ending with the Vertebrata, completing the whole with an alphabetical index to the fossils. The text-figures are explanatory diagrams of the structural features of regular and irregular Echinoderms, Brachiopods, Pelecypods, Gasteropods, and Cephalopods, and the plates provide sufficiently good figures of all the fossils described in the text. The book is cut to a convenient size for the pocket, and provides the worker in the field with a handy means of readily identifying the bulk of his finds on the spot. The English collector will find this book of considerable value for his own purposes.

C. D. S.

IX.—The Ore Deposits of South Africa. Part I: Base Metals (1908). Part II: The Witwatersrand and Pilgrimsrest Goldfields and similar occurrences. By T. P. Johnson. London: Crosby Lockwood & Son, 1909. Price 5*s.* net each.

THESE two small volumes are intended for the use of those technically connected with the mining industry and as a guide to the prospector.

In a country of such diversified geological structure as South Africa it is difficult to gauge the wants of those interested in the development of its mineral resources; but it may be as well, and sufficient, to state that the author ignores the stratigraphy of the country, since, in his opinion, the "principles of ore deposition" are independent of it.

Considering the high price and small size of these volumes we should have expected to find more original subject-matter, more carefully prepared maps and sections, and a greater economy of space both in the arrangement of the text and of the sections.

X.—Brief Notices.

1. Journal of Geology (Chicago).—In this Journal for October-November, 1909, there is an interesting article on the "Physical Geography of the Pleistocene, with special reference to Pleistocene Conditions", by Mr. R. D. Salisbury. He refers to evidence of greater depression during the glacial epochs than during the interglacial; also to the effect of increase of altitude on climate, leading to greater erosion and to the greater consumption of carbon dioxide whereby the temperature became lowered. Decay of rocks was checked by decrease of altitude or temperature, or by the accumulation of ice-sheets which protected the rock beneath from ready carbonation. The author refers also to the loading of the land-surface with ice over vast areas, to the consequent effect on crustal movement, and to the recurrent processes

of erosion and sedimentation by ice agencies. Finally he deals briefly with changes in life, which apart from mammals have been insignificant, observing that even among mammals it is not clear that the dying-out of species in one locality was contemporaneous with the disappearance of the same species in other localities.

Mr. Stuart Weller contributes the "Description of a Permian Crinoid Fauna from Texas", and Mr. S. W. Williston gives an account of "New or little-known Permian Vertebrates", with the description of a new genus of amphibian, named *Trematops Milleri*.

2. Philippine Islands.—Dr. Warren D. Smith has issued a report on *The Mineral Resources of the Philippine Islands* (Bureau of Science, Manila, 1909). He regards the future results of mining as promising. The gold production from lodes, decomposed rocks, and placer deposits rose in value from about £20,000 in 1907 to £50,000 in 1908. Coal, worked on Batan Island, amounts to 130 tons a day. There is a good deal of iron-ore, but at present there is only one furnace in operation, and this is owned and worked by a Filipina woman. Limestone and shale suitable for cement occur; and there are indications of petroleum, kaolin, manganese ore, and copper. Artesian water has been obtained in the great plain of Luzon.

3. Geological Survey of Canada.—Among publications issued in 1909 by the Canadian Department of Mines, we have received a report by Mr. D. B. Dowling on *The Coal-fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia*. The coal is found on three distinct horizons in the Cretaceous, separated by shales of marine origin. The lowest horizon is at the base of the system, and is considered to be Cretaceous from its flora. It lies just above the Fernie Shale, which is regarded as Jurassic. The coals include anthracite, bituminous coal, and lignite, and the author estimates that there is a total quantity of more than 143 thousand million tons in the provinces described.

In another report Mr. R. G. McConnell describes "The Whitehorse Copper Belt, Yukon Territory". The belt, as at present determined, extends for a distance of about 12 miles, and the principal ore bodies occur in limestone adjoining granite. The important economic minerals are the copper sulphides, bornite, and chalcopyrite; and they are associated in some cases with magnetite and hæmatite, in other cases with garnet, augite, and tremolite.

We have also received a useful *Catalogue of Publications of the Geological Survey, Canada*, revised to January 1, 1909.

4. Mining Magazine.—We have received a copy of the *Mining Magazine* for November, 1909, being No. 3 of vol. i. Although it deals essentially with the practical applications of geology, with mining and metallurgy, with companies, investments and speculations, and with problems of labour, it also contains reviews of books, and many miscellaneous paragraphs of scientific as well as economic interest. Some remarks are made on the British Radium Corporation, formed to work the pitchblende in the Trenwith Mine in Cornwall, and doubt is expressed whether it is a sound commercial undertaking.

There is an article by Mr. T. T. Read on "Coal Mining in Manchuria". The Fushun Mines, north-east of Mukden, are worked in Tertiary strata, which yield a soft bituminous coal. The total thickness of coal varies from about 150 to 270 feet, made up apparently of many seams closely associated. The greatest thickness without a parting is 32 feet, but the five seams worked are each from 9 to 12 feet thick. It is estimated that the production for 1909 may be about 700,000 tons. Apparently the coal was worked in very early times for the manufacture of pottery, as in making excavations on the ground large quantities of ancient Korean pottery and coins dating back to 300 B.C. have been discovered.

5. Geology of Bristol.—A concise and interesting *Sketch of the Geological History of the Bristol District*, by Professors C. Lloyd Morgan and S. H. Reynolds, has been published by the Bristol Naturalists' Society (Proceedings, vol. ii, pt. ii, 1909). It contains references to the principal published works, and embodies accounts of the more recent researches on the Silurian rocks, the Carboniferous zones, and the origin of the physical features.

6. Geological Survey of New Jersey.—The Annual Report of the State Geologist, Mr. H. B. Kümmel, for the year 1908 (1909), contains an account of the zinc mines of Sussex County, by Mr. A. C. Spencer. The ore minerals are principally franklinite, containing oxides of iron, manganese, and zinc; willemite, silicate of zinc, much of it containing manganese; and zincite, oxide of zinc, also with manganese. Mr. J. V. Lewis contributes a report on the Building Stones, illustrated with map, views of old and new buildings, and coloured plates of various granites, serpentine, marble, and other rocks.

7. Geological Literature added to the Geological Society's Library during the year ended December, 1908. 8vo. London (Geol. Soc.), November, 1909. Price 2*s*.—It is merely necessary to remind our readers that this valuable record of the geological work of the world is published for 1908. Mr. W. Rupert Jones, Mr. Belinfante, and Mr. C. H. Black have all contributed to the heavy task of getting it ready, and the publication fully maintains its position as the one indispensable work of reference for all geologists. An index of 76 pages to 113 pages of bibliography sufficiently indicates the exhaustive nature of the work and its utility.

REPORTS AND PROCEEDINGS.

Geological Society of London.

December 15, 1909.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, in the Chair.

The following communications were read:—

1. "The Skiddaw Granite and its Metamorphism." By Robert Heron Rastall, M.A., F.G.S.

The visible exposures of the Skiddaw Granite are three in number, all very similar; part of the more northerly one is a greisen, which

is not here dealt with. The normal granite is more or less porphyritic in structure, with large phenocrysts of perthite, in a coarse or fine-textured ground-mass of orthoclase, plagioclase, biotite, and muscovite. Various micrographic intergrowths occur, indicating in some cases eutectics of three or more components. No reliable analyses are available, but the rock is provisionally classed as an alkali-granite of Hatch's classification.

Evidence is brought forward to indicate that the granite is intruded along the axis of an anticline, with a strike approximately E. 15° N. and W. 15° S., the normal direction for the district.

The metamorphic aureole is very large, measuring about 6 miles from east to west and 5 miles from north to south. This is out of all proportion to the size of the visible exposures of granite, and it is inferred that the intrusion underlies a large area at a small depth.

Within this area three distinct rock-types can be recognized, namely, (1) black slates, (2) grey flags, (3) grey grits. The metamorphism produced in each of these is described in detail, and it is shown that the commonly accepted zones of alteration do not hold, since the rocks concerned were originally of very different character. The frequently described section in the Glenderaterra Valley runs across the strike, and includes both black slates and grey flags. The former never undergo a high degree of metamorphism, chiastolite being the characteristic mineral. The well-known cordierite-mica rocks of Sinen Gill are derived from the grey flags, and a very narrow zone close to the granite shows garnet and staurolite. The impure grey grits of the central band contain cordierite, andalusite, and mica, and garnets are only seen close to the contact with the Grainsgill greisen. The Carrock Fell intrusion produces little or no alteration in the grits, with which it comes into contact for a long distance.

The phenomena here displayed may be summed up as an example of a moderate degree of thermal metamorphism, due to the intrusion of a large mass of granite, at a comparatively low temperature, into a series of rocks of variable composition, which had previously undergone dynamic metamorphism. The most important minerals produced are cordierite, andalusite and chiastolite, biotite and muscovite, while garnet and staurolite are only found close to the granite. Owing to the variations of lithological composition across the strike, it has not been found practicable to divide the aureole into concentric zones, but the alteration is gradual and progressive towards the intrusion.

2. "The Metallogeny of the British Isles." By Alexander Moncrieff Finlayson, M.Sc., A.O.S.M., F.G.S.

The ore-deposits of the British Isles (tin, copper, lead, zinc, gold) are considered synthetically in their relation to igneous rocks and to tectonics. The four major epochs of igneous activity and crust-movement in the area were: pre-Cambrian, post-Silurian (Caledonian), post-Carboniferous (Hercynian), and Tertiary. A few insignificant ore-occurrences, including the stanniferous magnetite in the older granite-gneiss of Ross-shire, date from the pre-Cambrian. A group of pyritic fahlbands in the Highlands of Scotland, and the wolfram-bearing pegmatites of the Grainsgill greisen, date from the Caledonian,

accompanying the widespread province of Caledonian granites. The great bulk of the deposits of economic importance, including the veins of Cornwall and Devon, the lead, zinc, and copper veins in England, Southern Scotland, Wales, and Ireland, are of Hercynian (and Armorican) age. This is shown by the age of the fissuring in many cases (post-Carboniferous to pre-Triassic), by the absence of ore-veins in Jurassic or later formations, and by other evidence. The Tertiary volcanic period was not accompanied by ore-deposition, the evidence which has been adduced in favour of this in the Isle of Man, Cornwall, and Devon, and the North of England, being unsatisfactory.

The ore-deposits are classified in accordance with the above-mentioned metallogenetic epochs, and are divided into metallogenetic provinces, as has been done by Professor L. de Launay with the ore-deposits of Italy, Africa, and Siberia. The essential features of the different groups are summed up. The evidence, collected and sifted, indicates the following zones of ore-deposition :—

(1) Pneumatolytic zone: tin, passing up into copper.
(2) Deeper vein-zone: copper with gold. Lead and zinc subordinate.
(3) Middle and upper vein-zones: lead and zinc. Copper subordinate.

The conclusions drawn from the investigations are :—

(i) The importance of the physical conditions of the Permo-Trias in favouring ore-deposition in upper zones.

(ii) The close connexion between metallogenetic and petrographical provinces, and the essential dependence of ore-formation throughout geological time on the differentiation of igneous rocks accompanying great crustal movements. Differences in ore-deposits in different localities and regions appear to be due to primary differentiation of ores accompanying the differentiation of igneous magmas at successive epochs.

3. "The Geological Structure of Southern Rhodesia." By Frederic Philip Mennell, F.G.S.

The author describes in some detail a portion of what may be termed 'the Laurentian Area' of Africa. The oldest rocks include all lithological varieties, and exhibit most of the known types of alteration. They comprise a great development of hornblendic rocks (epidiorites and amphibolites); on the other hand mica-schists, and sheared rocks generally, are conspicuously absent. They include (1) 'basement schists' on which the altered sediments were laid down, and (2) altered basic igneous intrusions, simulating rocks of any previous age. All these are older than the granites by which they, and the metamorphic series, are invaded.

The vertically bedded 'ironstone series' is described, and is compared with similar rocks of the Lake Superior region. They are shown to be especially developed along the eastern border of Matabeleland, and their conspicuous banding is attributed to recrystallization of fine mechanical sediments under pressure.

The conglomerate beds (or Rhodesian 'Banket') are 10,000 feet thick, and rest unconformably upon the ironstone series in the west, both these formations being gold-bearing. But they overlap also elsewhere on to the 'basement series'; while they are represented

apparently in North Mashonaland by a thick series of grits, resembling microscopically the Moine Gneisses of the Scottish Highlands. The series contains pebbles of granite free from microcline, and banded ironstones.

The thick crystalline limestones overlying the conglomerate series contain chert and dolomite, the latter rock occurring also as an alteration product from serpentine. Graphite also is found, and is attributed to the insolubility of carbonaceous matter in a highly siliceous magma. Contact alterations of the limestones by the granites are described.

The granites occupy the greater part of the area dealt with, and their intrusive character as regards the metamorphic rocks is shown. The normal granites are biotite-bearing, and have microcline as the dominant felspar; they never contain hornblende or muscovite. Patches of micropegmatite are included in the microcline, proving that the 'eutectic' was not the final residuum of crystallization. Orthite, as well as epidote, occur in most sections cut from the Matopo Granite, and the author compares the mixed rocks of the gneissose edges of the granite with the 'Fundamental Gneiss' of Canada and other regions.

The sedimentary series is subdivided as follows:—

Zambesi Basin.	*Thickness in feet.*
Taba's Induna Series	200
Forest Sandstones and Basalts	1000
Escarpment Grits	400
Upper Matobola Beds (coal-bearing)	300
Busé Beds (local only?)	300
Lower Matobola Beds (coal-bearing	200
Sijarira Series	2000

Limpopo Basin.

Tuli Lavas.
Coal Beds.
Unconformity.
Sanksoto Sandstones.

No fossils are recorded, other than silicified wood, except in the coal-bearing beds, in which occurs *Palæomutela Keyserlingi* of the Russian Permian, as also plants.

Various igneous rocks are described, including the great mass of picrite extending nearly across Rhodesia, which the author considers to be intrusive along a thrust plane.

The paper concludes with a description of the diamond-bearing beds of Rhodesia, which resemble those of Kimberley, and also contain fragments of eclogite.

CORRESPONDENCE.

THE PRICE OF GEOLOGICAL SURVEY MAPS.

Sir,—A recent decision of the Treasury, that the prices charged for all Government publications should be sufficient to cover the cost of their production, is calculated to discourage the pursuit of science and

to prevent the spread of knowledge obtained at great cost. One result of this decision is that the price of almost all the hand-coloured Geological Survey Maps (the vast majority of those published) has been raised, in some cases preposterously; for instance, quarter-sheet 92 N.E., Pateley Bridge, is raised in price from 3*s.* to 14*s.* 3*d.*, quarter-sheet 81 S.E., Buxton, from 3*s.* to 8*s.* 3*d.* This means that while thousands of pounds are spent in geological surveying the results are inaccessible to the public except at an almost prohibitive price. It makes British geologists envy their friends in the United States, where the antediluvian hand-colouring is unknown, and a geological folio containing topographical geological economics, and structural map with explanation, can be bought for 25 cents (1*s.*). In Canada geological survey maps are supplied gratis to Canadians. I would gladly join in a memorial, or, if necessary, a deputation to the Chancellor of the Exchequer, to obtain the reversal of this penny-wise policy.—Yours sincerely,

BERNARD HOBSON.

TAPTON ELMS, SHEFFIELD.
January 6, 1910.

MISCELLANEOUS.

GEOLOGICAL SOCIETY, 1910, MEDALS AND AWARDS.—The Council of the Geological Society have this year made the following awards: The Wollaston Medal to Professor W. B. Scott, of Princetown University; the Murchison Medal to Professor A. P. Coleman, of Toronto University; the Lyell Medal to Dr. Arthur Vaughan; the Wollaston Fund to Mr. E. B. Bailey; the Murchison Fund to Mr. J. W. Stather; and the Lyell Fund jointly to Mr. F. R. Cowper Reed and Dr. Robert Broom.

THE GEOLOGICAL SURVEY OF EGYPT.—Dr. William Fraser Hume, Assoc.R.C.S. and Assoc.R.S.M., F.G.S., who has served for more than ten years as a Geologist on the Survey of Egypt, has now been appointed Director of the Geological Survey in the Public Works Department, Giza, Egypt. He has contributed many valuable papers on Egypt to the GEOLOGICAL MAGAZINE.

ERRATA.—"Old Granites of the Transvaal and South and Central Africa," by C. B. Horwood & A. Wade. The authors request to be allowed to make the following corrections:—In Part I (October, 1909), p. 455, l. 1, for "Just over *three* years ago" read "Just over *four* years ago". On p. 458, l. 11, for "*chrom*-iron" read "*chrome*-iron". In Part III (December, 1909), p. 543, 6th line down, after "the strike" add comma. On p. 546, l. 33, for "further east" read "north-west from there". On p. 546, l. 34, delete comma after "Gordonia" and insert a comma after "generally".